WIRE AND WIRE PRODUCTS

APRIL 1938

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What do you want in wire—a special analysis—or some quality of strength, temper, finish, knotting, crimping or coiling? Tell us what you need—write your own ticket—and we'll show you wire that meets your requirements. Republic Steel Corporation, Wire Division, 7850 South Chicago Avenue, Chicago, Illinois—General Offices, Cleveland, Ohio.
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BERGER MANUFACTURING DIVISION
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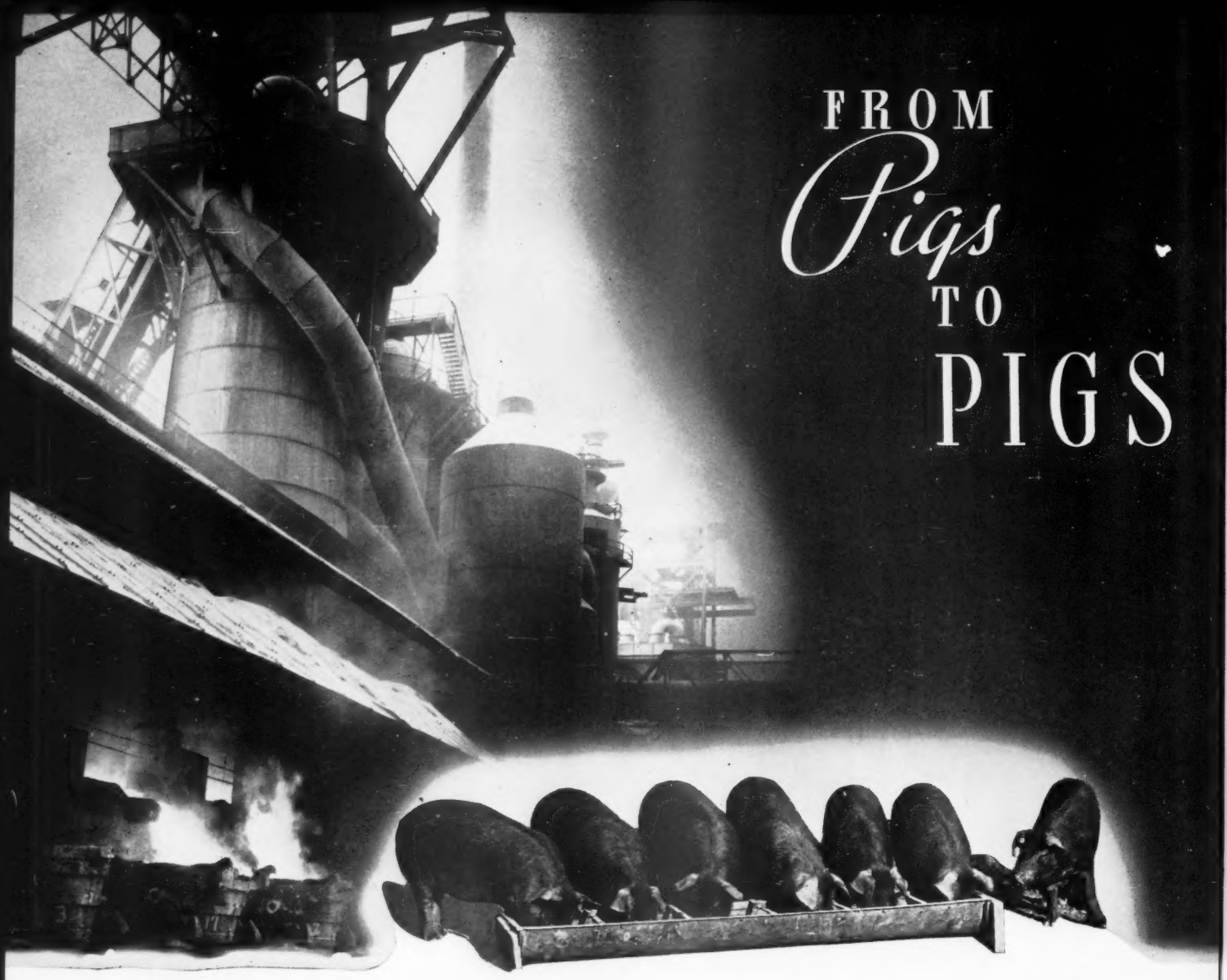
OFFICIAL PUBLICATION OF THE WIRE ASSOCIATION



FROM *Pigs* TO PIGS

★"Modern" applies today to farms as well as cities--and *steel* has made this true. A sizeable percentage of the "pigs" (masses of metal cast in a mold) from all blast furnaces find their way to the farms in the form of steel---in plows and in modern equipment which increases production; granaries that protect the harvest; pipe, pumps and troughs by which animals are fed and watered.

On an average farm are hundreds of uses for steel. Look around your home--whether farm or city--and note how much you, too, depend on steel --hinges, stoves, cooking utensils, refrigerator, plumbing, heating and countless other uses.

Not, of course, just any steel. There are actually thousands of kinds of steel, and we have spent years and millions of dollars to equip ourselves to work with you, to find which will exactly meet your needs. No matter how small the order may be every Youngstown resource for quality is employed in its production.

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Manufacturers of Carbon and Alloy Steels
General Offices - YOUNGSTOWN, OHIO

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Per .001" Die Wear

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☆ ☆ ☆

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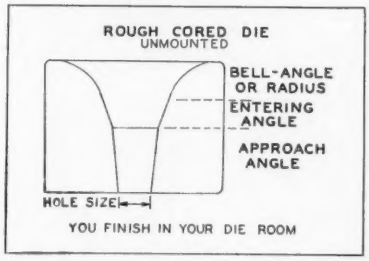

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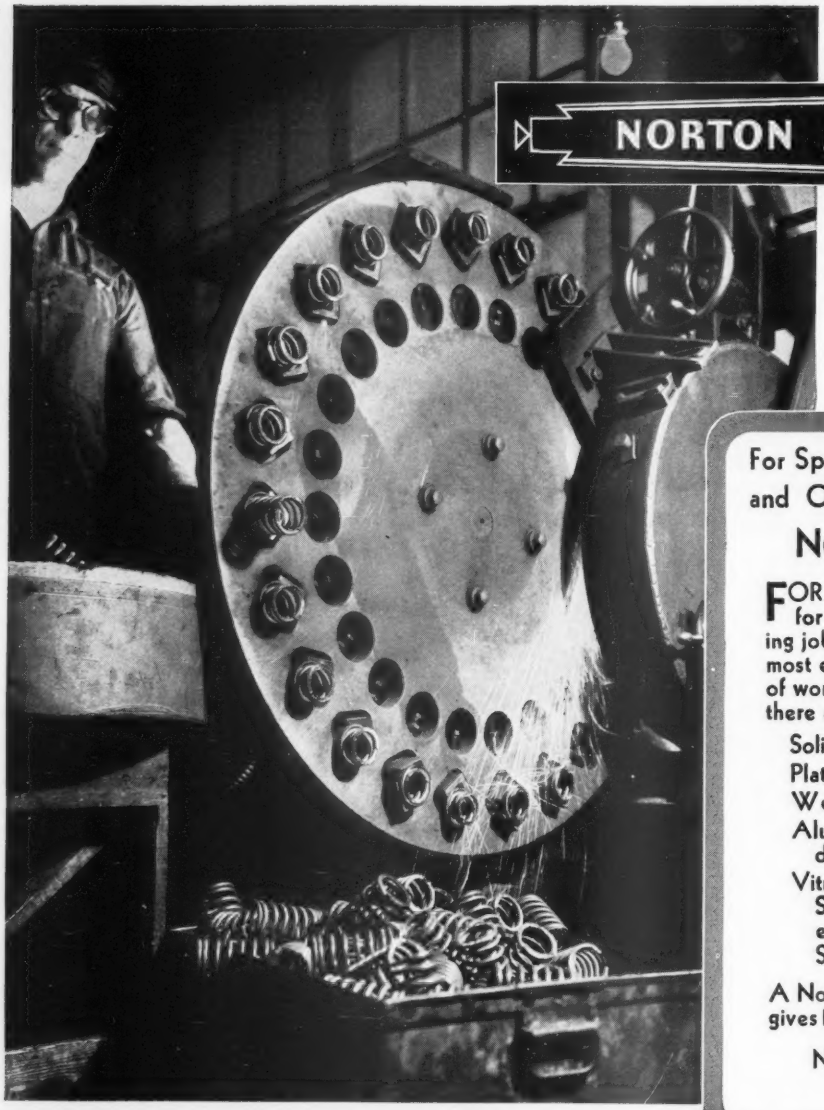

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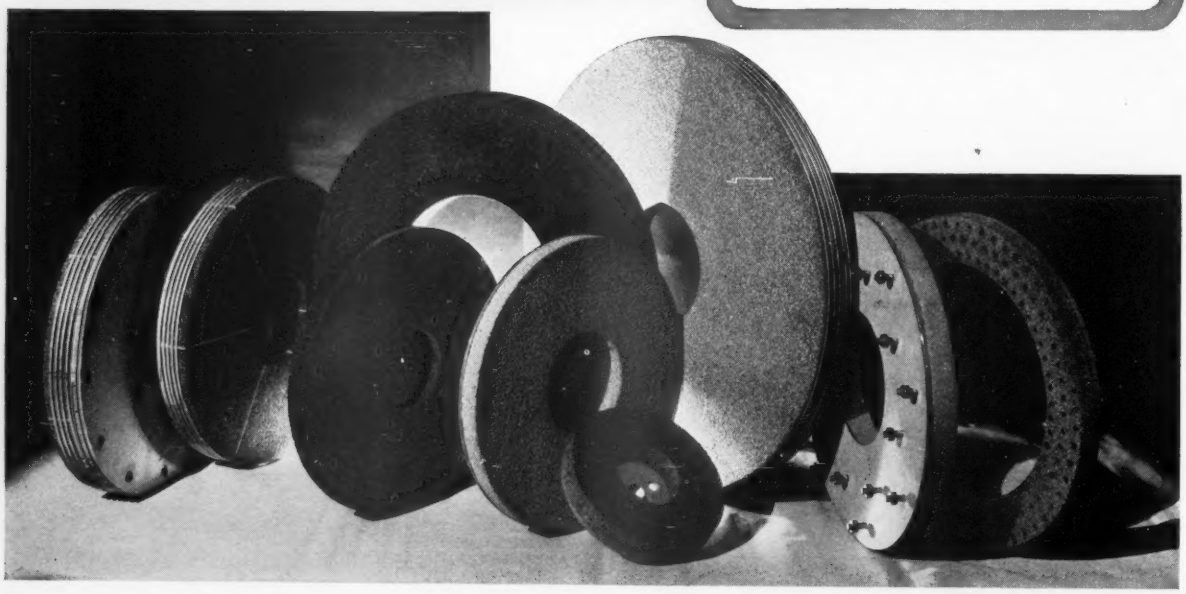

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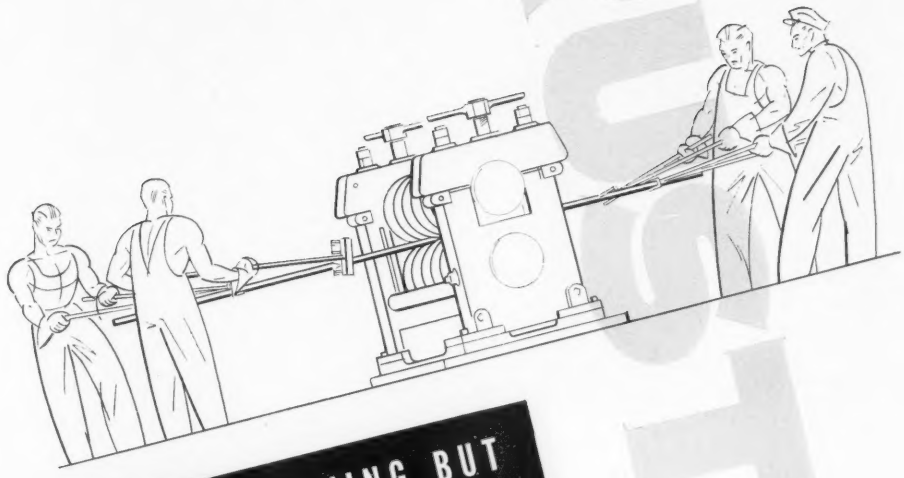

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3. A machine for many metals and alloys.

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2. A wide range of finishing sizes.
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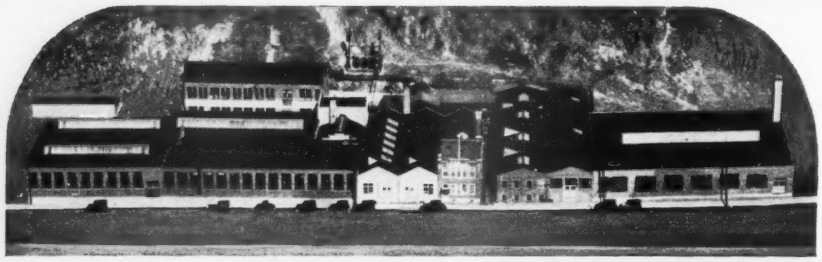

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* * *

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Phosphor Bronze
Pure Tin
Lead
Antimonial Lead
Cadmium
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False Gold and Special Brass and Bronze Alloys to Specification

* * *

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* * *

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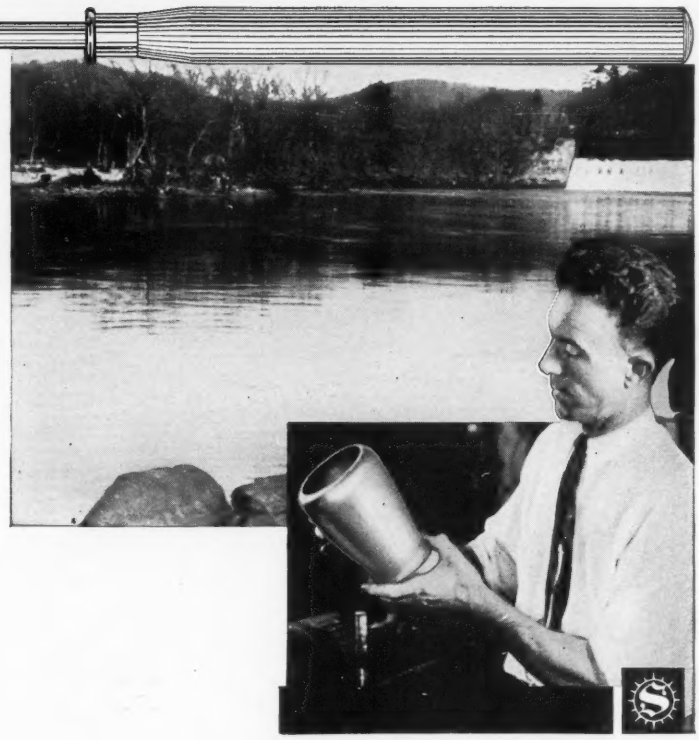
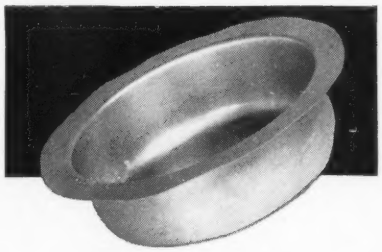
ESTAB. 1902 — Successors ROYLE & AKIN — ESTAB. 1902

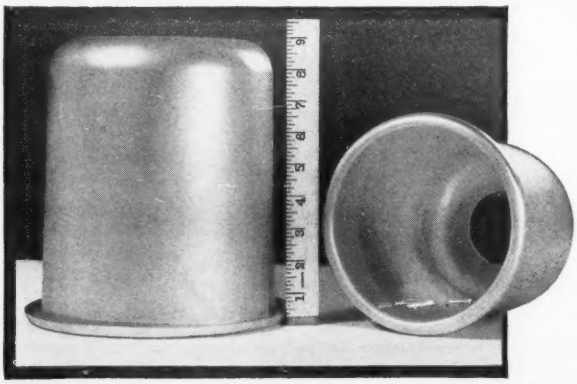
"Flows" as smoothly as a placid stream



IN drawing, spinning and stamping, Seymour Nickel Silver flows smoothly without strain, coming off so free from surface irregularities as usually to avoid a cutting down operation. It is especially economical for deep draws, often taking as many as four or five without anneals.

Even grain and uniform ductility, attained by combining high grade copper and zinc with virgin nickel under unceasing laboratory vigilance, account for the efficient performance of Seymour Nickel Silver—and, incidentally, its wide use by manufacturers of silverware, novelty ware, and similar articles for more than a generation.





Seymour Nickel Silver, in sheet, wire and rod, is supplied not only in varying ductilities, but in all degrees of hardness up to spring temper; also free cutting leaded rod in 18% and lower percentages of nickel content. Its silvery white color fits it admirably for plated ware; for, when exposed by wear, it leaves no yellow stain. Also it is ideal for unplated items because of its strong resistance to corrosion.

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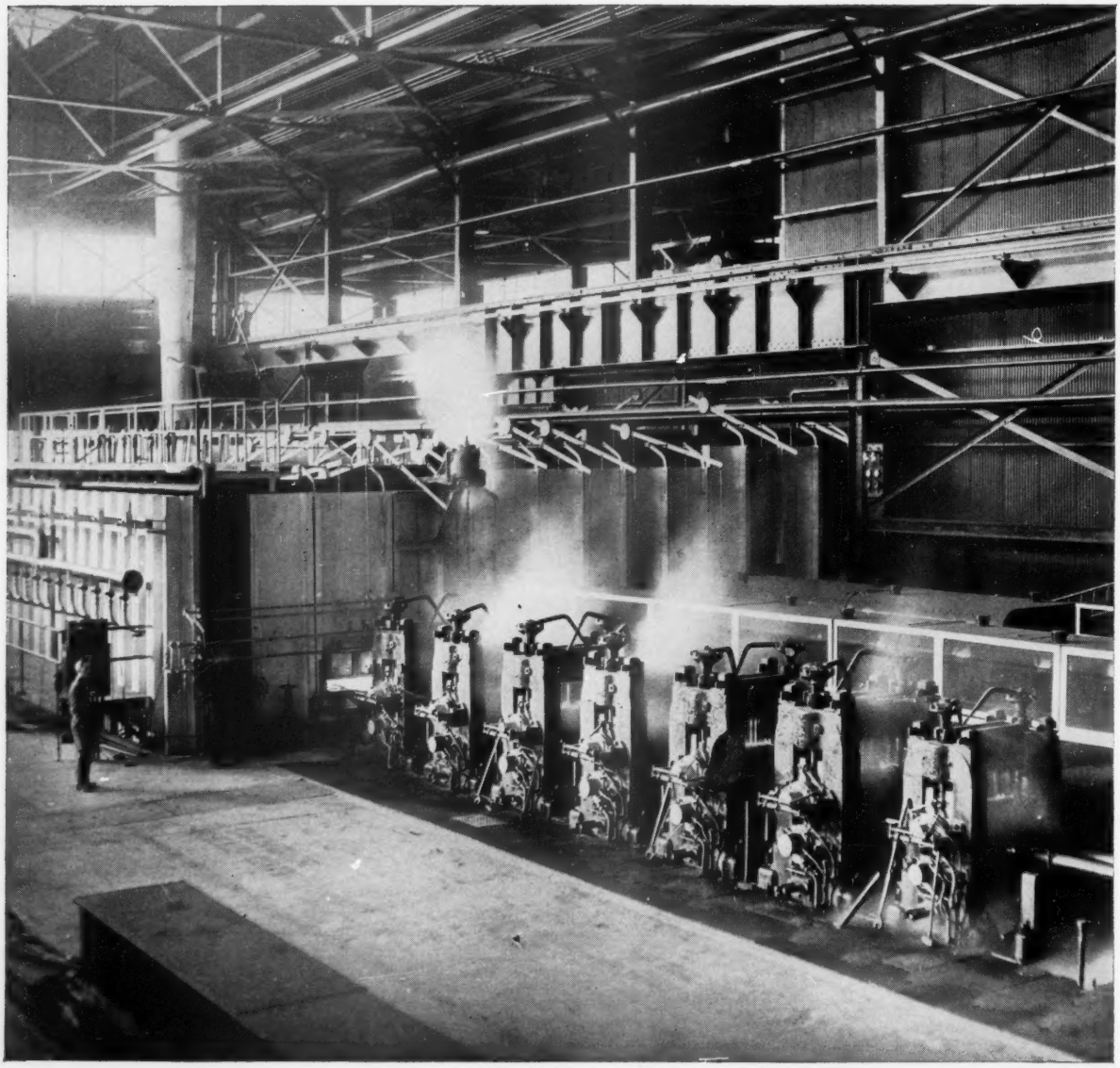
SEYMOUR NICKEL SILVER

for spinning, drawing, stamping, forming



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BETHLEHEM STEEL COMPANY

BETHLEHEM STEEL

You Can Start These Profits Working Right Now With---

MORRISON

BAKERS

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It's just as easy to install a Morrison Flash Baker in your cleaning house as to add another lime tank. Regardless of age or layout of your present system, these flash bakers will reduce hours of baking time to as many minutes, will save great floor space, conserve fuel. Time, effort, and the other costly elements of rod baking are minimized, and a better product is produced. Write for complete details of the new Morrison Flash Baker.

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Without such a machine, — conceived, built, and patented by us, — we would not be able to manufacture a semi-finished Carbide Die one step from finishing so inexpensively as to make any other plan of marketing Carbide Dies far too costly for the wire drawer.

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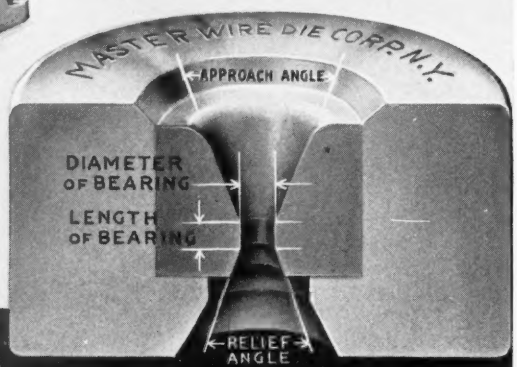

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WIRE AND WIRE PRODUCTS

A monthly publication devoted to the production of Wire, Rod and Strip, Wire and Rod Products and Insulated Wire and Cable

DRAWING—ROLLING—EXTRUDING—FORMING—FABRICATING

Vol. 13 APRIL, 1938 No. 4

Designated as

Official Publication By The Wire Association

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The Wire Association

Announces

A SERIES OF THREE LECTURES

By B. L. McCarthy,

Chief Metallurgist,
Wickwire Spencer Steel Co.,
Buffalo, N. Y.

Outlining the principles of metallurgy as applied to the wire industry.

Tentative titles are:

1. Critical Points of Metals.
2. Thermal Reactions of Metals.
3. Cold Working of Metals.

+ + +

THESE lectures will be in simple language, understandable by the non-metallurgist and will be presented as a part of the program of the Wire Association Meetings at Detroit, Michigan, October 17 to 21st inclusive.

+ + +

MEMBERS of the Wire Association will be entitled to attend these lectures without additional cost other than the regular registration fee for the meeting.

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WIRE AND WIRE PRODUCTS

A monthly publication devoted to the production of Wire, Rod and Strip.
Wire Products and Insulated Wire and Cable.
DRAWING --- ROLLING--- EXTRUDING --- FORMING --- FABRICATING

Vol. 13 APRIL, 1938 No. 4

The Manufacture of Steel Wire And Some Related Processes

By J. L. Schueler,
General Superintendent,
Continental Steel Corp., Kokomo, Indiana.

PART I

Wire is demanded by the trade in so many sizes, analyses, tempers and finishes that its manufacture is probably the most complex in the steel industry. It is hoped that this brief article will afford some help to the buyer of wire in furnishing basic information of assistance in preparing specifications. ✦ ✦

A Short History of Wire Drawing

THERE is scarcely an art, or trade, that is as old as wire making. It is described in the Bible in some detail.

✦ ✦ ✦

IT is highly probable that in the earliest times metals were beaten with a hammer into thin plates, or leaves, which were afterward divided into small strips by means of scissors or other instruments. The strips were then rounded by means of a hammer and file to form wire.

✦ ✦ ✦

THE period when attempts were first made to form such strips into wire by drawing the metal through holes in a die, cannot be determined exactly. It is certain, however, that the first wire made in this manner was drawn by hand. The fundamental methods used in early times for drawing wire were substantially the same as those now in use. Wire dies were used in England early in the fifteenth century because the making of wire dies was then known as a particular trade. In fact, the wire drawers at that time were organized so that each man had his own particular field of work, as, for example, smithmen, brakemen, girdlers, middlemen, card-wire drawers, crockers, card makers and fish hook makers.

✦ ✦ ✦

THE smith reduced the bars to convenient sizes for the brakeman. The brakemen drew these bars through a coarse wortle (die) by means of a hand lever or brake, from which the term "breakdown", still in use today, has been derived. The girdlers annealed the wire and the middlemen were the cleaners who prepared the wire after annealing for further manipulation. The card wire drawer, corresponding to the fine wire drawer of today, finished the wire to the size required by the card maker. The card makers made the hand cards formerly used in preparing wool for cloth making. The crocker cut the wire into short lengths and crocked, or bent it, ready for the production of cards or fish hooks.

✦ ✦ ✦

WIRE has been made in America since about 1650; wire making and the manufacture of wire nails being quite an industry in the New England states even prior to the Revolutionary War.

✦ ✦ ✦

Manufacture of Wire

THE beginning of the cycle for producing or manufacturing wire, is the iron ore. Iron ore is an earthy, or rock-like material, usually found in the form of an impure iron oxide. In many instances this material has substantially the same analysis as iron rust, although its physical characteristics may be different.

✦ ✦ ✦

ASSUMING the composition of the ore to be substantially iron

Designated as Official Publication by the Wire Association

oxide, the next manufacturing step is concerned with the separation of the iron from the oxygen. This is done by heating the ore, together with coke and limestone, in a large shaft furnace called a blast furnace. The carbon of the coke separates the oxygen of the ore from the iron, while the limestone fluxes out the earthy impurities of the ore to form slag.

✦ ✦ ✦

THE molten iron, plus some additional remaining elements such as carbon, phosphorus, silicon, sulphur and manganese, is tapped from the blast furnace and cast into pig iron. Pig iron is high in carbon (about 4 per cent) and for this reason is very brittle. It has no commercial value except for remelting purposes.

✦ ✦ ✦

PURE iron itself, is difficult to melt. It is soft, tough and malleable, both when hot or cold. However, when carbon unites with iron in high percentages, as in pig iron, the physical properties of the iron are completely altered in that it becomes

1. **More fusible,**
2. **Very brittle, and**
3. **Cannot be forged either hot or cold.**

Thus we have what the general public calls cast iron.

✦ ✦ ✦

IN the trade, however, the term "cast iron" is applied only after the pig iron has been remelted and cast into some finished form. The product of the blast furnace is always spoken of as "pig iron" if it is allowed to cool in molds, and "hot metal" if it is used for further processing without first being allowed to solidify. Pig iron is the foundation stone of the whole iron and steel industry; it is one of the great staples of commerce throughout the world.

✦ ✦ ✦

Steel Making Processes

THE fundamental steel making processes are:

1. **Wrought iron (not a "steel" in the true sense of the word)**
2. **Crucible Steel.**
3. **Bessemer Steel.**
   - **A. Acid**
   - **B. Basic**
4. **Open Hearth Steel**
   - **A. Acid**
   - **B. Basic**
5. **Duplex Steel**
6. **Electric Furnace Steel**
   - **A. Acid**
   - **B. Basic**
7. **Triplex Steel**

✦ ✦ ✦

Wrought Iron

ALTHOUGH the crucible process is the oldest known for the manufacture of steel, the first large scale production of ductile ferrous metal was the manufacture of wrought iron by means of the puddling process.

✦ ✦ ✦

THE puddling process being a small tonnage producer the wrought iron manufacturer, in order to compete was forced to develop a process which would allow wrought iron to be made more economically. This led to the development, in 1930, of the Aston process. There are other processes for making material similar to wrought iron such as the "bushelling" process. Very little wrought iron is used in the manufacture of wire.

✦ ✦ ✦

Crucible Steel

THE manufacture of crucible steel is almost described in its name, the steel being made in crucibles. The process consists in melting together in a clay-graphite crucible, a suitable charge of scrap iron, pig iron and charcoal.

✦ ✦ ✦

AFTER the charge has been placed in the crucible, the latter is covered and placed in a coke fire. The crucible is kept tightly closed during the melting process to prevent infiltration of air. After the charge has melted, the crucible is removed from the fire, and the molten steel poured into suitable molds. The usual charge in a crucible weighs approximately 100 pounds. A good grade of steel can be made by this process, but on account of the high cost of production it is gradually being replaced by electric furnace steel. Little, or no wire is made from crucible steel.

✦ ✦ ✦

Bessemer Process

THE Bessemer process for steel making consists in blowing air through molten pig iron in a pear shaped vessel called a converter. The pig iron is brought directly from the blast furnace while fluid, or it may be remelted in cupolas. The Bessemer process may be either acid or basic, the process used depending upon the composition of the pig iron. In the case of the Acid Bessemer process the heat is maintained in the molten metal due to the oxidation of the silicon by the oxygen of the air which is blown through the molten pig iron, whereas in the Basic process the heat is maintained by the oxidation of phosphorus.

✦ ✦ ✦

NO large removal of sulfur is made in either the Acid or Basic Bessemer process, and, consequently, the iron used must be low in sulfur. In the Acid Bessemer process neither phosphorus nor sulfur is removed and, consequently, the pig iron must be low in both these elements. Bessemer tonnage has decreased in this country since the turn of the century. A fair tonnage of wire is made from Bessemer steel.

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Basic Open Hearth Steel

THE term "Basic Open Hearth" steel refers to the type of furnace in which the steel is made, the bottom of the furnace being lined with a basic material.

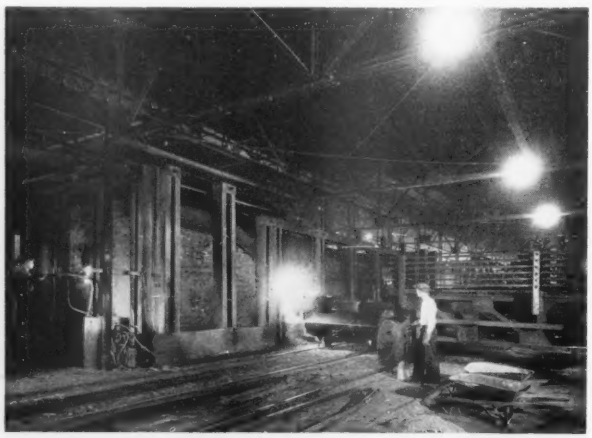

Fig. 1. Charging an open hearth furnace.

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THE furnace bottom, itself, takes little part in the manufacture of the steel except to determine the character of the refining operations which can be carried out in the furnace. It is necessary in the manufacture of steel to remove the sulfur and phosphorus to as low a point as possible. In order to do this, it is necessary to use a fluxing material which will remove these elements. As such a fluxing material is always of a "basic" nature, the bottom of the furnace must also be basic so as not to take part in the refining actions. Consequently, the charge in a Basic Open Hearth furnace consists of pig iron, scrap and limestone. The metallic charge is then melted by flames which are directed over the bath alternately from opposite ends of the furnace. During the course of the melting operation the silicon and carbon of the charge are oxidized and enter the slag together with the manganese and some of the iron.

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THIS slag, when it becomes basic (high in lime) removes phosphorus from the molten metal and also aids in the removal of sulfur. By far the largest amount of wire is produced from basic open hearth steel.

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Acid Open Hearth Steel

THE difference between the Basic and the Acid processes is due principally to the lining of the furnace bottom, the Acid furnace being lined with a siliceous material (sand). As was previously stated, the character of the bottom determines the kind of the slag that can be carried, and the slag determines the chemistry of the process.

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IN the Acid Open Hearth process a mixture of pig iron and steel scrap is charged into the furnace and melted. When the mass is melted, iron ore is added, the oxygen of the ore oxidizing the excess carbon until the required composition is attained. As a rule, nothing, except possibly some ore or scale, is added to form a slag, because the oxidation of the silicon and manganese, together with some iron that is oxidized, usually affords a sufficient supply of slag. Sometimes a small quantity of lime is added to help shape up the slag. Acid slag is about half silica (SiO_2) while the other half is composed largely of oxides of iron and manganese.

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THE important feature of this process is, that the acid slag will not remove either phosphorus or sulfur; consequently, these elements are not eliminated from the metal as in the Basic process. Therefore, the metallic charge must be low in these elements. Only a relatively small tonnage of Acid Open Hearth steel is manufactured in this country. Practically all wire made from this kind of steel is used for cables, ropes and the like.

Duplex Process

SOMETIMES a Bessemer pig iron, in which the phosphorus and sulphur are rather high, is available for steel manufacture.

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THE Bessemer process, of course will not remove these elements. For this reason, the Duplex process was devised, whereby the pig iron is blown in a Bessemer converter to remove the silicon, and part of the carbon, the molten metal being then transferred to a large Basic Open Hearth furnace where the phosphorus and sulfur are removed. There are also some special cases where duplexing is used. Very little wire is produced from duplex steel.

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Electric Furnace Steel

THERE are a number of types of Electric furnaces such as the resistance type; the induction type; and the high frequency type, and furnaces up to 100 tons melting capacity are used.

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BOTH acid and basic processes are used in the manufacture of electric furnace steel. There is some wire made from electric furnace steel.

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Processing of the Steel

THE steel as soon as it reaches its proper degree of refinement, except for crucible steel, is tapped from the furnace into a large, thimble shaped receptacle called a ladle, from whence it is teemed into ingot molds. When the

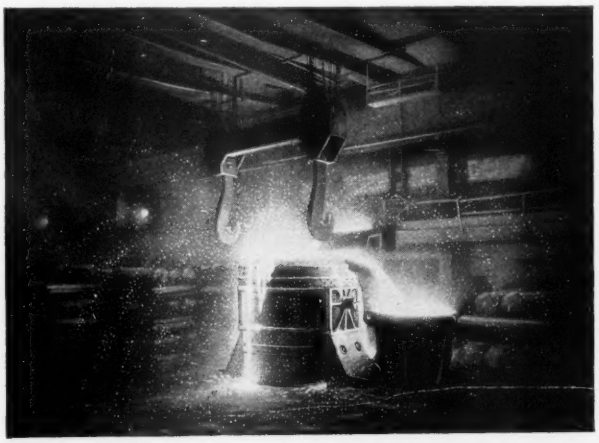

Fig. 2. Steel running into ladle from furnace and slag overflow into slag pot.

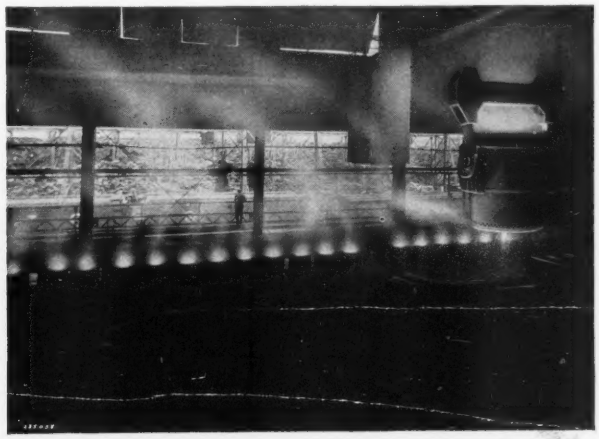

Fig. 3. Teeming steel into moulds.

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steel ingots have solidified sufficiently, the molds are removed, and the ingots placed in furnaces called soaking pits. Here the ingots are reheated, or, if hot, are brought to a uniform temperature throughout. After the ingots have attained a temperature suitable for rolling, they are taken, one at a time, to a blooming mill, where they are given a suitable number of passes between rolls to reduce the section of each ingot to a bloom. Thus, an ingot 6 feet long and 22 inches square (with a small taper from bottom to top) is reduced in the blooming mill to a very much longer section about 6 inches square. The bloom may then pass without reheating to a bar mill, which further reduces the bloom to a much longer section 1¾ inches square, called a billet. This section is so long that it must be cut into smaller lengths for subsequent operations, so that one ingot may be rolled into from twenty to thirty or more billets, the number depending on the size of the ingot and the length of the billets desired.

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BILLETS are then taken to the rod mill furnace and reheated to a rolling temperature. The rod mill may be a continuous type in which the sections pass continuously from one stand of rolls to the other in a straight line so that the reduction from the billet to the finished rod is a continuous process; or it may be a Garrett mill, which, instead of having the rolls in a straight line longitudinally of the passage of the steel section, have them set substantially side by side so that before the section from one stand can pass to the next stand it must be turned 180 degrees. This may be accomplished by either manual operation or by mechanical devices called repeaters. Combinations of these two types of mills are extensively used. A standard rod is No. 5 gauge and has a nominal diameter of .218 inch (7/32 inch) although rods up to 47/64 inch diameter are also rolled on rod mills.

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RODS weigh about 300 pounds per bundle, or coil, although both lighter and heavier weight bundles are produced, depending on the kind, or type, of rod mill.

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DEFECTS in rods may be size, shape, slivers, fins, pipes, segregation, laps, seams, twists, surface decarburization and variation in hardness. There are other defects but these are the principal ones. These defects will be mentioned later, when we discuss the drawing of wire from the rods.

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Cleaning the Rod

THE rod, as it comes from the rod mill, is covered with scale. Scale is a hard, brittle oxide of iron, formed at relatively high temperatures and having a composition substantially Fe_3O_4.

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BEFORE rods can be drawn into wire, the scale must be removed, because scale acts as an abrasive and either cuts out the hole in the drawing die, or causes the wire to break, or both.

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WHEN the rods are brought into the cleaning house from the rod storage, or directly from the rod mill, they are strung on a holder, called a yoke or pin, which holds anywhere up to a ton or more of rods. The yoke of rods is then picked up by a crane and immersed in a tank containing a hot dilute sulphuric acid solution. The tank may be one of several, arranged in a circle served by a central crane, or the tanks may be arranged in a straight line and served by an overhead traveling crane.

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THE concentration of the acid runs from one to three per cent or more, by volume, the amount of acid used depending on the amount of scale, the degree of its adherence to the rods, and the time of the cleaning cycle. The temperature of the solution is kept at approximately 180 degrees Fahr. If the rods have been finished at a very high temperature, and have not been quickly cooled, they are apt to be heavily scaled, whereas rods finished at a lower temperature, or rods which have been quickly cooled, have relatively little scale and, consequently, may be cleaned with less acid. The acid solution does not dissolve the scale, but removes it more or less mechanically by means of hydrogen, which, forming under the scale on the steel, lifts it from the steel.

(*Please turn to Page 204*)

Fig. 4. Drawing ingot from soaking pit. ✦ ✦ ✦

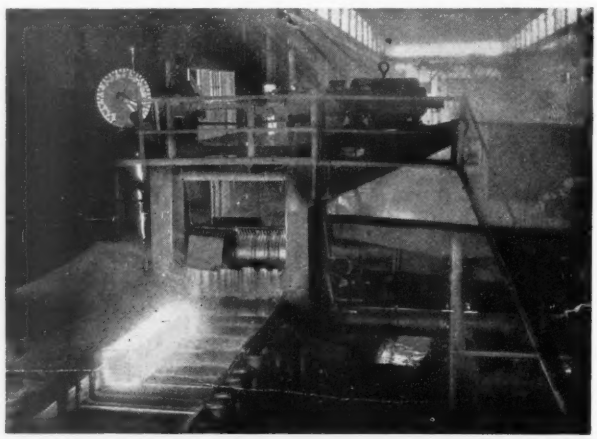

Fig. 5. Rolling ingot in 35 inch blooming mill. ✦ ✦

Some Scientific Aspects of The Pickling Problem

By E. Herzog
Chief of Research Engineering, Usines de Pompey

Translated from "Metaux & Corrosion" by Kenneth B. Lewis.

A technical analysis of some problems encountered in the pickling operation. ✦ ✦ ✦

THE surfaces of ferrous metals are usually covered by a film of oxides resulting from either the action of oxidizing gasses at high temperatures or electrochemical action at room temperature. The operation of removing these oxides may be called pickling, in the case of rolling scale, and cleaning in the case of rust. The term pickling may also be applied to the removal of other deposits, such as non-ferrous metals, tin, zinc, and the like for the purpose of their recovery.

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FOR many reasons it is necessary, at times, to remove the oxide films. The reason may be to permit the bonding of a protective covering, zinc, tin, cadmium, nickel, chromium, aluminum, paint, varnish, or enamel. Or the object might be to permit cold work, stamping, wire drawing, or it might be to permit arc welding, gas welding, or spot welding. In many of these cases either scale or rust causes defects, failures, or excessive wear of tools and dies.

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IT is the writer's purpose to discuss some aspects of the pickling problem, particularly from the scientific viewpoint.

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Physical and Chemical Nature of Scale

ACCORDING to Pfeil the scale formed on heating steel to 900° C comprises, from surface inward, layers of $Fe^2 O^3$, $Fe^3 O^4$, and Fe O. The instability of Fe O, as demonstrated by Chaudron, results in the formation of a mixed layer of $Fe^3 O^4$ and Fe when the temperature is held a long time below 570° C. According to Pfeil, if the iron coalesces with the $Fe^3 O^4$ in large grains the acid attack will be very slow, but if, on the contrary, there are fine grains of Fe in a matrix of $Fe^3 O^4$, the attack on this matrix will be rapid; the outer layers of scale will be detached and cleaning will be greatly speeded. It may be supposed that numerous couples, Fe—$Fe^3 O^4$ start a vigorous electrolysis.

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THE conductive oxides such as $Fe^3 O^4$ give from .8 to 1 volt e.m.f. with iron in sulphuric acid, with a current of the order of 2 milliamps per square centimeter, resistance varying from 5 to 15 ohms per millimeter. $Fe^2 O^3$ is a poor conductor and will not act as a cathode. Its physical nature (a smooth compact film) tends to seal the metal away from the acid.

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OTHER elements present in iron affect the physical and chemical nature of the oxides. MnO forms solid solutions with $Fe^3 O^4$ probably reducing its conductivity, the resulting scale being an insulator. Oxide of cobalt raises the transformation point of $Fe^3 O^4$ (Benard and Chaudron).

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THE oxides of certain metals give rise to various reactions in the solid state at high temperatures, for example:

(a) elements more easily oxidized than iron, whose oxides have higher heats of formation than those of iron, such as chromium, silicon, and aluminum, seem to form oxides concentrated at the surface of the metal, which seem to interpose a barrier to emission of electrons; they cut down the rate of oxidation.

(b) oxides of metals less easily oxidized than iron, as copper and nickel for example, are reduced at the expense of iron.

$$Cu\,O + Fe \rightleftharpoons Fe\,O + Cu$$

Hence there is a concentration of such elements at the surface, especially above 1100° C.

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$FE^2 O^3$, Fe O, $Fe^3 O^4$ NiO, and MnO are soluble in the mineral acids. The oxides of aluminum, silicon, tungsten and chromium are soluble in alkalis. Their solubility depends naturally on their fineness of grain and their porosity. As is well known, an oxide formed at high temperature or cast, is resistant to acid attack, while if formed at low temperatures it dissolves readily.

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SOLUTION of iron oxides is more rapid in the presence of an underlying metal, which can be taken as proof of an electrolytic action.

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CONDITIONS of fabrication differ widely, and the nature, especially physical, of the oxides varies over a considerable range. Slow cooling may cause a part of the scale to drop off; finishing at a dull red heat, possibly involving cold work, gives a glassy adherent scale very hard to pickle off.

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Methods of Removing Oxides

AN ideal pickling would consist in a complete and rapid separation of the scale with no effect on the base metal. Unfortunately

the mineral acids attack iron, and when there are resistant areas of scale the spots first laid bare are apt to pit. Another complication is that there may be absorption of hydrogen by the metal, with resulting brittleness and loss of ductility. It is true that such brittleness disappears in time, and, if the metal is heated to 100°—150° C. the time required is short, but in some cases, notably .80 carbon steel, it lingers (see Bullard-Dunn process). These considerations give rise to another problem: how to protect the metal during the dissolving of the scale.

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METHODS in common use for the separation of scale from metal are:

(a) Mechanical
(b) Chemical
(c) Electrochemical.

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(A) Mechanical Methods

WE shall mention only a few methods, as others have been presented in an article by F. Kappler.

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A JET of water at 75 kg. pressure, striking an oxidized surface at the proper angle, blows off all but a very thin film. This method is used for de-scaling flat products coming out of a hot mill, and may be seen at Acieries d'Hagondange and at numerous American steel plants. Other methods are sand blasting and shot blasting, which involve a slight amount of cold work. In the light alloys cold work may accelerate corrosion and is prohibited in Germany for airplane parts.

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SAND blasting gives steel a clean and attractive surface but one which rusts quickly. It is an excellent preparation for surfaces to be covered with metal, zinc, cadmium, or aluminum, or to be painted. It is also necessary in spot welding, for without sand blasting the welds would be porous and brittle. The process is too costly for large tonnages involving high percentage of surface but it is practical in ship building and repair.

(B) Chemical Processes

SOME of the products of a steel plant, such as automobile sheets, and strips for stamping, are pickled at the mill before delivery. In the case of products to be galvanized, tinned, or nickel or chrome plated, the pickling is done in conjunction with these coating operations. The reagents are the mineral acids, particularly muriatic, sulphuric, phosphoric, and, in special cases, nitric. Muriatic and sulphuric acids are generally used with substances called inhibitors, which limit the solvent action to the scale.

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MORE than 150 simple substances and mixtures are known to have this inhibiting effect in steel practice, most of which are organic. They may be classified, according to their action as follows:

(a) Substances which increase the over-voltage of the hydrogen
(b) Substances which increase resistance on the liquid-metal contact.

It is practically impossible to measure these effects separately; all measurements include some elements pertaining to each.

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THE expression "resistance on the liquid-metal contact," according to Munger, covers the effect of the organic film on the negatively charged metal in varying electrical resistance, raising the over-voltage of the hydrogen, electrostatic repulsion, etc.

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Theory of Inhibiting Effect

STEEL plunged into acid takes on a negative charge because of the establishing of a double electrical film. The attraction exercised by these negative charges varies from point to point. Positive ions are first drawn toward the most strongly negative zones; and usually molecular hydrogen is set free at those points:

$$H^+ + e = H \qquad H + H^+ = H^{2+}$$
$$H^{2+} + e = H^2$$

Assume that there are ions in the solution which make deposits which impede that H+H reaction; the solvent action will slow down through polarization of the cathodes. Mineral salts that deposit metals at high over-voltage interfere with the evolution of hydrogen, and act as inhibitors. The elements of groups V and VI of the periodic classification act thus: for example, salts of arsenic and antimony, and organic "onium" compounds with tetravalent atoms, such as:

$$=C=O\#$$
$$=S=$$
$$=N=$$

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Salts of Arsenic and Antimony

ARSENIC and antimony salts act as inhibitors only in certain circumstances. The effect of antimony tri-chloride is secured by using it in a strong muriatic acid mixture (35%), from which metallic antimony deposits as a thin adherent film. From dilute acid the deposit will be spongy and feebly adherent, and the inhibiting effect of little or no value.

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THE acid solution of $SbCl^3$ protects steel, nickel, and cobalt, but it hastens the solution of zinc, cadmium, tin, and chromium. The inhibiting effect is pronounced in the case of chrome or carbon steel, mediocre in the case of forged products, and weak in the case of cast iron.

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THE selective feature of $SbCl^3$ is useful in determining the amount of zinc and tin in coatings. The solution dissolves not only the pure metals but the alloy layers, Fe-Zn, Fe-Sn, because of which a correction factor must be used. In tinned products the error is of the order of 3%.

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THE metallic films deposited by electrolysis or cold dipping dissolve at varying speeds. The most satisfactory results are secured by the use of 2% oxide of antimony in muriatic acid of 1.14 to 1.16 specific gravity. The antimony film is very thin, about $1.2\ 10^{-8}$ millimeters on soft steel

after an hour's immersion in the oxide mixture of 1.14 gravity.

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ARSENIC deposits as a metal, as shown by Burgess and Engle, and later by Watts. Arsenic is cathodic to iron; it raises the over-voltage in the same way as antimony.

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THE selective action of these elements is explained by Clarke as follows: when a metal is dipped into a solution of $SbCl^3$ the cations (Sb) tend to deposit metallic antimony and simultaneously hydrogen tends to be disengaged. In the case of iron, nickel, and cobalt, the discharge of Sb ions is the more rapid, and the disengagement of H^2 in bubbles is impeded by the adherent film which supplies an over-voltage greater than the electromotive force Fe-Sb. In the case of zinc, cadmium, and tin, the deposition of antimony and the disengagement of hydrogen are simultaneous; the over-voltage is lower than the e.m.f. betwen antimony and these metals, and the effect of local couples comes into play.

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REMOVAL of rust is accomplished by the use of a well heated mixture of 100 parts concentrated HCl, 2 parts Sb^2O^3, and 5 parts of stannous chloride crystals. The formation of ferric chloride (shown by a yellow tinge) stimulates attack on the iron, hence $SnCl^2$ is used as a reducing agent. A de-rusting bath should contain this salt. A bath is sometimes prepared as follows:

1—Dissolve 0.2 parts As^2O^3 in 30 parts concentrated HCl.

2—Mix 0.5 parts $SnCl^2$, 1 part 40% formaldehyde and 68.3 parts water.

THESE two are mixed just before use, and because of the formation of $FeCl^3$ the life of the reagent is limited. The disadvantage of this last bath is its feeble acidity. The muriatic acid-antimony solution previously described works much faster.

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Action of Organic Compounds

ORGANIC compounds can act as inhibitors provided they are soluble, ionize in acids, contain a tetravalent element, are not decomposed by acid, and do not prevent the solution of oxides. Generally speaking, the substances which meet these requirements are of the group:

C=O= (oxonium)
=S= (sulphonium)
N

The last is the best known and the best understood.

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THE diagram above shows the mechanism of absorption of the ions which replace hydrogen in the Helmholtz double film. This film forms at the cathodic (negative) poles, and covers the surface like paint. If the film is continuous and impermeable to H^+ ions, protection is complete.

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ACCORDING to Mann, the positive charge is concentrated in the N (S) atom of the ionized compound. The inhibitor attaches itself to the surface through its nitrogen or sulphur. It is the orientation of the ion, whether perpendicular or inclined, which determines the amount of surface presented by its section parallel to the metallic surface, and its film thickness, and it is probably those factors which affect diffusion of the H^+ ions.

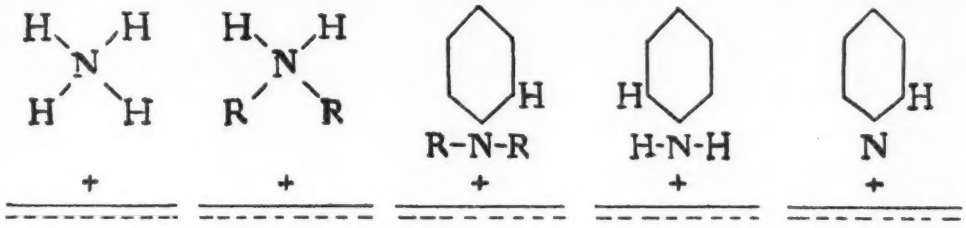

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TABLE I shows that the relative inhibiting values of the aliphatic chains, varies with their length. This is proof that the chains are inclined to the metal surface, because the normal section of all these molecules is the same (CH^2) and if they took up a position perpendicular to the metallic surface there would be no difference between them.

TABLE 1

Compound	conc. N	Efficiency as inhibitor
methylamine	0.25%	20%
ethylamine		26
propylamine		34
amylamine		61
tri-N-butylamine	0.25	97
mono-N-butylamine		45
tri-N-amylamine	0.25	99.5
mono-N-amylamine		62
aniline	0.25	38
propyl-aniline		93
dimethyl-aniline		70
di-butyl-aniline		99
pyridine	0.25	55
quinoline		87
acetone		13
ethyl propyl ketone	0.50% =C=O	49

IN the heterocyclic compounds, such as pyridine, the nitrogen is the nucleus, as in the body-centered iron atom. The pyridine molecule is probably perpendicular to the metallic surface, but if such a molecule is rendered dissymmetric by the attachment, for example, of a phenyl group, as in quinoline, the ionized group is inclined, and its inhibiting value increases. If a second group, C^6H^5, is attached, as in acridine, the molecule is again symmetrical, and though it is of greater bulk than that of quinoline its inhibiting value is lower because of its symmetry. These examples, from Mann's numerous studies, show that one can not only explain but predict the inhibiting values of organic compounds.

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THE inhibiting effect of organic compounds is due to an adsorbed film, and it is possible to trace isotherms of adsorption (see Freundlich), by using the logarithm of the inhibitor content as ordinate and the efficiency (diminished iron loss) as abscissa.

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THE organic inhibitors do not possess the selective power of arsenic and antimony; they inhibit for all metals.

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MUNGER has put forward a formula linking efficiency to molecular weight.

$$E = \frac{(M)^{1.83}}{(15.3)}$$

Efficiency is expressed as $E = \frac{Vac. - Vac.i}{Vac.} \times 100$ in which Vac. represents loss of weight in uninhibited acid, and Vac.i loss of weight with inhibitor. Inhibiting value can be determined by laboratory tests. It is suggested that tests be carried out at temperatures used in practise, 60° to 80° C., and that the solution be steamed, as in regular practice.

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Bullard-Dunn Process

THE difficulties inseparable from ordinary pickling have led to efforts to devise processes to avoid them. In the automobile industry a large amount of chromium plating necessarily implies careful preparation of surfaces for the best possible appearances of the finished job, and the Bullard-Dunn process has been developed for such preparation, especially for bumpers.

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THE work is the cathode, and the anodes are lead, graphite, or duriron. The electrolite is sulphuric acid, 47.5 grams per liter, or muriatic 10.3 plus sodium chloride 22.5 grams per liter, temperature 82° C., and current density 8 amperes per square decimeter. Duriron anodes are the most economical; they become covered with a thin siliceous film which retards oxidation of the ferrous ions. The formation of ferric salts slows down the action, which is normally of 3 to 5 minutes duration.

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THE addition of lead or tin salts prevents pitting, a thin film of lead or tin being deposited on the cleaned surfaces and acting as a rust prevention in subsequent storage. If it is desired to remove this metallic film it will come off quickly if the work is made the anode in a bath of 90 grams NaOH and 30 grams Na^3PO^4 per liter.

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THE limit of iron content for fast work is 22 grams per liter. The process has the virtues of uniform and rapid de-scaling and complete absence of embrittlement by hydrogen.

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Conclusions

IT has been shown that scientific study can explain certain phenomena of corrosion and of protection in de-scaling and de-rusting. Progress in industrial plants will be advanced by more exact knowledge of the physical and chemical natures of oxides, a field relatively unexplored. The problems of industrial pickling are to secure the lowest possible cost, more speed, and a technique for more extensive surfaces as for instance beams 70 to 80 feet long. Collaboration of industrialists, metallurgists, physicists, and chemists will eventually bring the best solution.

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Supplement

SINCE the preparation of this article there have been published the results of later researches, which it seems worth while to summarize here.

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Electrolytic Pickling

CATHODIC treatment in acids causes brittleness, but in alkaline baths the hydrogen does not penetrate the metal (F.C.Lea.) According to Baukloh and Zimmermann, cathodic treatment in pure acid does not embrittle steel, but there are impurities such as arsenic, antimony, sulphur, selenium, and tellurium, which tend to form hydrides, which in turn promote the diffusion of hydrogen into the metal.

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ANODIC treatment has the advantage of not causing such diffusion. Sutton and Laban recommend such a treatment in 30% sulphuric acid with 20 grams per liter potassium bichromate. With current density of 95 amperes per square meter the surface will be clean and passive. Muller and Harant suggest treatment in 0.1% sulphuric in the presence of ferrous sulphate.

(Please turn to Page 206)

The Problem of Employment of Men Over 40

By Frederick A. Westphal
Superintendent, Wire Mills,
Sheffield Steel Corp., Kansas City, Mo.

An address over Station WHB, Kansas City, Mo., of the Mutual Broadcasting Company, in co-operation with the American Legion in its efforts on behalf of unemployed veterans. ✦ ✦

APART of the preamble to the American Legion Constitution states "For God and Country we associate ourselves together for the following purposes: To inculcate a sense of individual obligation to the community, state and nation; To foster and perpetuate a one hundred per cent Americanism". With such potent words of obligation, as an American Legionnaire I wholeheartedly join in presenting for your consideration and thought this economic problem facing us of providing employment for men over forty years of age.

✦ ✦ ✦

IT is desired to not only express consideration for World War veterans who average forty-four years of age, but **all** fellow citizens that, unfortunately, are unemployed at this time.

✦ ✦ ✦

LET us analyze this problem by four phases:-

✦ ✦ ✦

FIRST: What is the status of the economic conditions today in relation to employment of men over forty years of age? In the Durable Goods industry, of which the steel industry is a large portion, 40% of employes are over 40 years of age. In that 40% are the men of experience, stability, loyalty, matured judgment, controlled habits, good conduct, discipline and resourcefulness. It speaks for itself that men over forty are most valuable, and furthermore they are not apt to be led astray by radicalism, or foment unreasonable labor agitation. Many other industries, that are the backbone industries of the nation, coincide with the Durable Goods industry in such a performance of age employment.

✦ ✦ ✦

SECOND: What is the reason for this appeal and program of action sponsored by the American Legion? Many men have been unfortunate in losing their jobs through bankruptcy of concerns; liquidation or obsolescence of businesses; mergers have taken place that rearranged personnel and caused some to lose out; lastly, the volume of business is now in temporary recession (we hope for not too long), that causes curtailment of forces throughout the nation. For men unemployed by the aforementioned reasons it makes it doubly hard, especially when they have passed forty years of age. For men with exemplary records and who are breadwinners for families there should be profound sympathy, and employers should investigate and it would reveal many worthy and valuable workers that should have consideration where and when opportunities materialize.

FREDERICK A. WESTPHAL,
Superintendent, Wire Mills, Sheffield Steel Corp., Kansas City, Mo. Mr. Westphal, President of The Wire Association, is a prominent member of the American Legion in Kansas City, and incidentally was one of the first American officers to be wounded in Cantigny early in 1918. Mr. Westphal's artillery unit was badly shot to pieces and Mr. Westphal himself, was severely wounded.

✦ ✦ ✦

THIRD: What is the nation as a whole going to do about it? Since we are emphasizing the need of competent men over forty years of age becoming employed, we should have a crystal clear understanding of that fact in this discussion and there should be no misunderstanding on what is to follow in my statements here.

✦ ✦ ✦

IN our multifarious departments of government of federal, state, county and municipal, there is an approximate ratio of one person in the government service to seven salaried and wage earners in industry. Supervisors of government employes should doubly bear in mind, if this is not being done throughout the nation at this time, that whether it be partisan or non-partisan, that men over forty possessing inherent matured judgment and stability of character should be given the fullest consideration on opportunities for jobs.

✦ ✦ ✦

FURTHERMORE, in the Civil Service there are listed 1700 occupations that a portion are being examined upon periodically whenever vacancies occur. Here World War veterans in most cases have age limitations waived and are given at least 5% additional in

(*Please turn to Page 208*)

Editor's note—For the past several weeks, WHB, Kansas City, Mo., has presented well known business men and outstanding Legionnaires who have discussed various phases of the subject of unemployment of men over 40. Mr. Westphal's address, which is presented herewith, is significant in that it reflects the attitude of an organization which numbers many hundreds of workers on its payrolls.

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J. W. Rockefeller, Jr., Section Editor.

Vol. 13 APRIL, 1938 No. 4

Research On Fatigue Properties of Heavy Helical Springs

PART IV

By C. T. Edgerton, Chairman,

A. S. M. E. Research Committee On Mechanical Springs

Progress report number three of the sub-committee on heavy helical springs of the Special Research Committee on Mechanical Springs of the American Society of Mechanical Engineers. ✦ ✦ ✦ ✦ ✦

Fatigue Tests on Series "F" Springs of Plain Carbon Acid O. H. Steel Section VII

MATERIAL used was from acid open hearth heat No. 3490 of the Crucible Steel Company of America, La Belle Works. Chemical composition:

Carbon	**1.05**
Manganese	**.33**
Phosphorus	**.022**
Sulphur	**.025**
Silicon	**.13**

✦ ✦ ✦

THREE-QUARTER inch round spring bars were rolled and sheared to 83½" long, tapered on both ends, and fabricated into springs in "as rolled" condition and surface finish. The springs were coiled hot, to graduated heights ranging from 11.38" for Spring F-1 down to 7.45" for F-13. The corresponding range of pitch measurements was from 1-27/32" to 1⅛". Approximate mean helix diameter was 3¾", to give a spring index of 5. Springs after coiling were cooled in air.

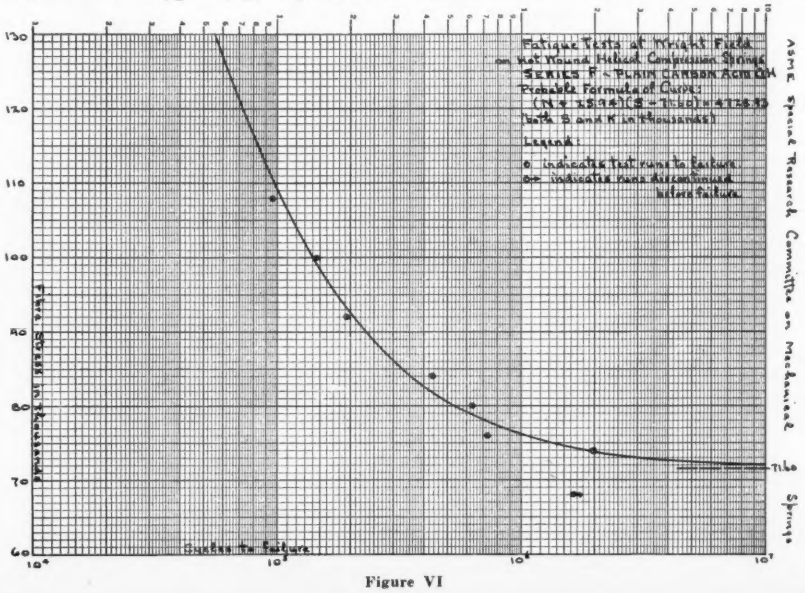


Figure VI

✦ ✦ ✦

Heat Treatment

SPRINGS were reheated to a temperature of 1550° F., quenched in oil, drawn for one hour (at temperature) in a lead bath at 825° F., and air cooled. Brinell hardness measurements, on pilot pieces wired to the springs during treatment, was 415.

✦ ✦ ✦

Calibration Tests

SPRINGS were first compressed solid a number of times in a hydraulic spring tester, with the following results:

Spring No.	Free Initial Hgt	Initial Pitch	Times Solid	Free Final Hgt
F-1	**11.38"**	**1.84"**	**25**	**8.56"**
F-2	**9.80**	**1.56**	**10**	**8.41**
F-3	**9.82**	**1.50**	**14**	**8.30**
F-4	**9.03**	**1.44**	**12**	**8.15**
F-5	**9.03**	**1.44**	**12**	**8.10**
F-6	**8.36**	**1.25**	**10**	**7.87**
F-7	**8.33**	**1.25**	**10**	**7.80**
F-8	**8.07**	**1.22**	**10**	**7.72**
F-9	**7.98**	**1.22**	**10**	**7.62**
F-10	**7.75**	**1.19**	**10**	**7.57**
F-11	**7.75**	**1.16**	**10**	**7.55**
F-12	**7.54**	**1.13**	**10**	**7.40**
F-13	**7.45**	**1.13**	**10**	**7.41**

✦ ✦ ✦

ENDS of the springs were then ground to a square bearing in a Gardner Disc Grinder.

✦ ✦ ✦

THE calibration tests were conducted in the same manner as those on previous groups covered

by this report. Complete test data are given in Table XII. Measurements were taken on prick punch marks spanning four active coils, on springs F-1, F-4, F-8 and F-12. Springs were then forwarded to Wright Field for the fatigue tests, together with six straight pieces which had gone through the heat treatment wired to the springs. These were intended for tension and torsion tests.

✦ ✦ ✦

AT Wright Field the test procedure was substantially identical with that on Series "A" springs. Tests with a magnaflux apparatus disclosed no cracks. Measurements, loads and stresses, and results of the fatigue tests are set forth in Table XIII.

✦ ✦ ✦

A MATHEMATICAL analysis of the endurance test results was made, to determine the probable equation of the stress-endurance curve. It was found to be:

$$(N + 25.94)\ (S - 71.60) = 4728.93$$

in which both S and N are in thousands. The fatigue test data, and curve for this equation, are shown graphically in Figure VI.

✦ ✦ ✦

ATTENTION is invited to the very good correlation of the datum points for the endurance runs with the theoretical curve. In part at least, this was undoubtedly the result of careful selection of the test stresses for the individual springs, so that these stresses have roughly a fixed relation to the "solid" stress. See remarks on this subject in Section Four.

Springs Series F. TABLE XII Calibration Tests

Loads in Pounds	Overall Heights: Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average	Loads in Pounds	Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average
	Spring F-1							Spring F-2					
Free	8.410	8.490	8.450	8.396	8.442	8.419	Free	8.181	8.170	8.176	8.146	8.137	8.142
500	8.087	8.075	8.081	8.131	8.124	8.128	500	7.831	7.822	7.827	7.819	7.814	7.817
1000	7.727	7.717	7.722	7.630	7.619	7.625	1000	7.433	7.422	7.428	7.397	7.386	7.392
1500	7.328	7.317	7.323	7.210	7.201	7.206	1500	7.063	7.054	7.059	6.991	6.984	6.988
2000	6.973	6.964	6.969	6.846	6.836	6.841	2000	6.685	6.674	6.680	6.669	6.660	6.665
2500	6.520	6.509	6.514	6.440	6.430	6.435	2500	6.327	6.318	6.323	6.273	6.261	6.267
3000	6.109	6.099	6.104	6.050	6.042	6.046	3000	5.942	5.933	5.938	5.905	5.893	5.899
3500	5.644	5.632	5.638	5.632	5.622	5.627	3500	5.584	5.575	5.580	5.509	5.497	5.503
Solid	5.231	5.233	5.232				Solid	5.283	5.272	5.278			
	Spring F-3							Spring F-4					
Free	8.119	8.163	8.141	8.090	8.146	8.118	Free	7.995	7.963	7.979	7.853	7.937	7.895
500	7.803	7.793	7.798	7.793	7.770	7.782	500	7.605	7.595	7.600	7.606	7.601	7.604
1000	7.419	7.410	7.415	7.400	7.390	7.395	1000	7.266	7.257	7.262	7.211	7.205	7.208
1500	7.056	7.046	7.051	7.021	7.009	7.015	1500	6.905	6.894	6.900	6.847	6.840	6.844
2000	6.702	6.684	6.693	6.635	6.621	6.628	2000	6.575	6.566	6.571	6.454	6.448	6.451
2500	6.328	6.318	6.323	6.252	6.238	6.245	2500	6.198	6.188	6.193	6.121	6.115	6.118
3000	5.929	5.919	5.924	5.878	5.863	5.871	3000	5.835	5.825	5.830	5.768	5.764	5.766
3500	5.541	5.531	5.536	5.552	5.535	5.544	3500	5.489	5.478	5.484	5.477	5.468	5.473
Solid	5.266	5.237	5.252				Solid	5.279	5.315	5.297			
	Spring F-5							Spring F-6					
Free	7.896	7.911	7.904	7.867	7.885	7.876	Free	7.732	7.718	7.725	7.715	7.700	7.708
500	7.570	7.557	7.564	7.584	7.574	7.579	500	7.420	7.409	7.415	7.446	7.437	7.442
1000	7.204	7.194	7.199	7.210	7.197	7.204	1000	7.060	7.051	7.056	7.080	7.069	7.075
1500	6.824	6.812	6.818	6.828	6.813	6.821	1500	6.720	6.708	6.714	6.714	6.704	6.709
2000	6.497	6.486	6.492	6.439	6.399	6.419	2000	6.354	6.343	6.349	6.382	6.370	6.376
2500	6.155	6.142	6.149	6.068	6.053	6.061	2500	6.067	5.994	6.001	6.033	6.024	6.029
3000	5.757	5.744	5.751	5.754	5.739	5.747	3000	5.667	5.654	5.661	5.684	5.673	5.679
3500	5.387	5.375	5.381	5.442	5.427	5.435							
Solid	5.283	5.265	5.274				Solid	5.341	5.327	5.334			
	Spring F-7							Spring F-8					
Free	7.595	7.594	7.595	7.581	7.580	7.581	Free	7.508	7.480	7.494	7.488	7.452	7.490
500	7.254	7.242	7.248	7.296	7.286	7.291	500	7.149	7.137	7.143	7.177	7.167	7.172
1000	6.928	6.918	6.923	6.936	6.937	6.937	1000	6.832	6.822	6.827	6.853	6.843	6.848
1500	6.613	6.603	6.608	6.596	6.586	6.591	1500	6.485	6.475	6.480	6.507	6.500	6.504
2000	6.256	6.246	6.251	6.276	6.266	6.271	2000	6.168	6.156	6.162	6.163	6.165	6.164
2500	5.932	5.921	5.927	5.946	5.938	5.942	2500	5.811	5.800	5.806	5.806	5.795	5.801
3000	5.578	5.567	5.573	5.628	5.618	5.623	3000	5.496	5.485	5.491	5.536	5.527	5.532
Solid	5.281	5.261	5.271				Solid	5.265	5.485	5.375			
	Spring F-9												
Free	7.469	7.519	7.494				2000	6.135	6.120	6.128			
500	7.134	7.123	7.129	Not	Taken		2500	5.822	5.807	5.815	Not	Taken	
1000	6.800	6.788	6.794				3000	5.458	5.443	5.451			
1500	6.468	6.455	6.462				Solid	5.250	5.224	5.237			

Loads in Pounds	Overall Heights Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average	Loads in Pounds	Overall Heights Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average
	Spring F-10							Spring F-11					
Free	7.356	7.403	7.380	7.342	7.386	7.364	Free	7.427	7.360	7.394	7.409	7.350	7.380
500	7.028	7.015	7.022	7.106	7.096	7.101	500	7.037	7.020	7.029	7.128	7.117	7.123
1000	6.686	6.675	6.681	6.765	6.754	6.760	1000	6.673	6.657	6.665	6.788	6.774	6.781
1500	6.369	6.359	6.364	6.403	6.390	6.397	1500	6.315	6.298	6.307	6.379	6.366	6.373
2000	6.019	6.004	6.012	6.054	6.043	6.049	2000	5.981	5.968	5.975	6.060	6.046	6.053
2500	5.678	5.666	5.672	5.744	5.732	5.738	2500	5.690	5.676	5.683	5.749	5.732	5.741
3000	5.385	5.370	5.378	5.485	5.472	5.479	3000	5.361	5.348	5.355	5.441	5.424	5.433
Solid	5.354	5.229	5.292				Solid	5.223	5.203	5.213			
	Spring F-12							Spring F-13					
Free	7.258	7.262	7.260	7.240	7.253	7.247	Free	7.139	7.262	7.226	7.175	7.251	7.213
500	6.912	6.901	6.907	6.990	6.981	6.986	500	6.889	6.881	6.885	6.950	6.945	6.948
1000	6.575	6.572	6.574	6.646	6.635	6.641	1000	6.529	6.520	6.525	6.614	6.604	6.609
1500	6.250	6.238	6.244	6.306	6.295	6.301	1500	6.189	6.184	6.187	6.254	6.244	6.249
2000	5.933	5.921	5.927	5.968	5.957	5.963	2000	5.883	5.875	5.879	5.923	5.912	5.918
2500	5.670	5.633	5.637	5.666	5.655	5.661	2500	5.541	5.531	5.536	5.600	5.589	5.595
Solid	5.296	5.303	5.300				Solid	5.308	5.298	5.303			

Deflection Readings on Four Active Coils

Loads in Pounds	Spring F-1 Compression	Spring F-1 Release	Spring F-4 Compression	Spring F-4 Release	Spring F-8 Compression	Spring F-8 Release	Spring F-12 Compression	Spring F-12 Release
Free	5.25	5.23	5.01	4.91	4.72	4.70	4.53	4.48
500	5.04	5.04	4.77	4.72	4.48	4.50	4.31	4.34
1000	4.78	4.70	4.54	4.47	4.29	4.27	4.09	4.11
1500	4.52	4.41	4.31	4.23	4.04	4.05	3.87	3.89
2000	4.30	4.17	4.10	4.00	3.83	3.82	3.66	3.67
2500	4.00	3.91	3.85	3.76	3.59	3.58	3.43	3.43
3000	3.74	3.65	3.60	3.52	3.37	3.38		
3500	3.41	3.40	3.33	3.30				
Solid	3.03				3.20		3.12	

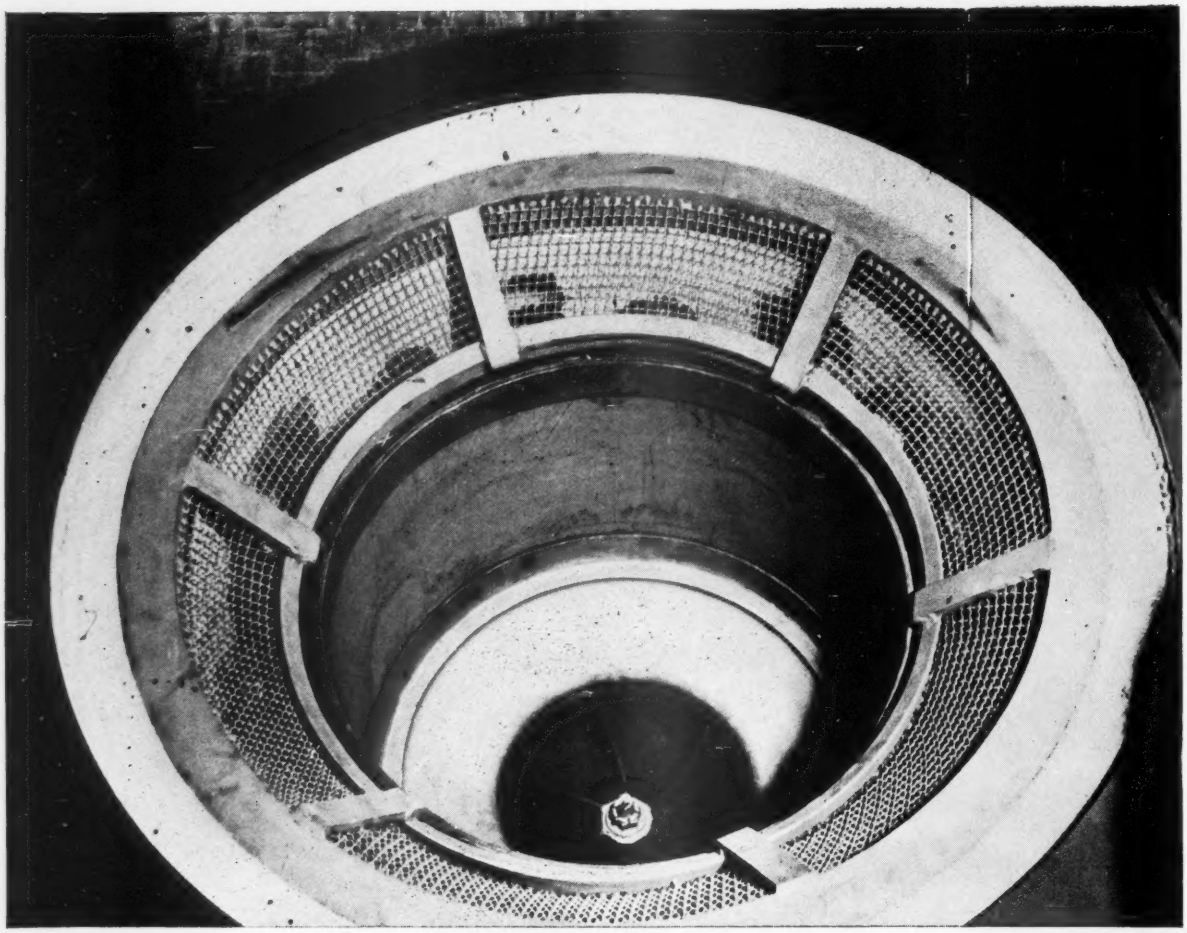
Spring Measurements and Development of Constants

Spring No.	F-1	F-2	F-3	F-4	F-5	F-6	F-7
Size of Bar (1)	.744″	.738″	.746″	.740″	.746″	.744″	.747″
Outside Diameter (2)	4.601″	4.578″	4.579″	4.559″	4.559″	4.559″	4.551″
Mean Helix Diameter (3)	3.801″	3.787″	3.780″	3.770″	3.763″	3.768″	3.758″
Spring Index (4)	5.109	5.131	5.067	5.098	5.044	5.065	5.031
Rover-Wahl Correction Factor	1.3029	1.3015	1.3058	1.3036	1.3074	1.3059	1.3083
M. F. S. per 1000-lbs. Load — Conventional Formula	23504	23995	23183	23778	23079	23300	22960
M. F. S. per 1000-lbs. Load — with Rover-Wahl Cor.	30623	31229	30272	30997	30173	30427	30039
Capacity Solid—lbs.	3950	3940	3845	3750	3685	3500	3540
M. F. S. Solid — Conventional Formula	92840	94540	89140	89170	85050	81550	81280
M. F. S. Solid — with Rover-Wahl Cor.	120960	123040	116390	116240	111190	106490	106340

Spring No.	F-8	F-9	F-10	F-11	F-12	F-13
Size of Bar (1)	.745″	.747″	.743″	.748″	.748″	.744″
Outside Diameter (2)	4.557″	4.550″	4.546″	4.555″	4.544″	4.533″
Mean Helix Diameter (3)	3.766″	3.759″	3.760″	3.764″	3.754″	3.748″
Spring Index (4)	5.055	5.037	5.057	5.032	5.019	5.038
Rover-Wahl Correction Factor	1.3067	1.3079	1.3065	1.3082	1.3091	1.3078
M. F. S. per 1000-lbs. Load — Conventional Formula	23192	23010	23296	22903	22842	23177
M. F. S. per 1000-lbs. Load — with Rover-Wahl Cor.	30305	30095	30436	29962	29902	30311
Capacity Solid—lbs.	3170	3330	3155	3235	3070	2850
M. F. S. Solid — Conventional Formula	73520	76620	73500	74090	70125	66050
M. F. S. Solid — with Rover-Wahl Cor.	96070	100220	96025	96930	91800	86390

(1) Average of six measurements.
(2) Average of six measurements, not corrected for pitch angle.
(3) Corrected for pitch angle (perpendicular to helical axis).
(4) Ratio—Mean Helix Diameter/Size of Bar.

(Please turn to Page 204)



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Vol. 13 APRIL, 1938 No. 4

Factors That Influence The Use of Metals

By B. L. McCarthy,

Chief Metallurgist, Wickwire Spencer Steel Company, Buffalo, N. Y.

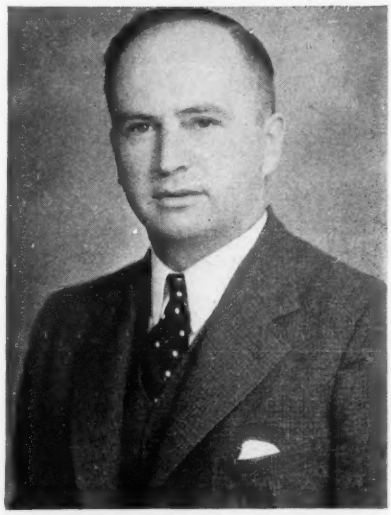
The most important factor which influences the use of metals is the ability to develop physical characteristics for specific purposes by alloying, heat treatment and cold working. A paper presented before the Pittsburgh Regional Meeting of the Wire Association, April 1, 1938. + + + + +

IN view of the important part that metals play in our everyday life, it seems in order to consider the factors which influence their use. Needless to say, the various factors and the variety of applications are numerous and it would require more time and space than is available at this time to elucidate on each. I will, however, attempt to bring out the more important ones in an effort to place before you some fundamental principles.

+ + +

Definition of Metals

THE definition of a metal is not clear. It has been defined as those elements which, in combination with hydrogen or oxygen or both, form a basic salt; also as those elements which deposit at the cathode during electrolysis. Neither of these definitions are absolutely accurate, as there are exceptions in both cases. In general, metals are considered as elements which combine strength with a reasonable amount of ductility, are conductors of heat and electricity and have a "lustre." Our present usage of the word metal, is not confined alone to elements which display the properties described above but embraces a variety of combinations of metals with other metals and non-metals which make up the enormous list of alloys of present day use.



BENJAMIN LEWIS McCARTHY

Born in Lockport, New York, in 1895. In 1913 was employed as Assistant Chemist by Simonds Saw and Steel Co. In 1916 was employed by Wickwire Steel Co., now known as Wickwire Spencer Steel Co., as Assistant Chief Chemist. Three years later was promoted to Chief Chemist and Metallurgist. Now in charge of the Chemical and Metallurgical Laboratories and directs research and special investigation into the Chemistry and Metallurgy of steel, steel wire and wire products. Member of the Wire Association, The American Society for Testing Materials, and the American Society for Metals. Awarded the Wire Association Medal for the most meritorious paper on wire manufacture or fabrication during the years 1935 and 1937.

+ + +

The Metals

IN Table I is shown a list of metals.(1) Other elements such as carbon display some metallic characteristic and are sometimes called 'near metals.' Many of the metals, because of their rarity or limited use in the metallic state have no place in our present discussion. Potassium and Sodium are examples of elements which display metallic characteristics in the pure state but are seldom employed in this condition. Other metals such as Titanium, Vanadium, Cobalt, Antimony, Manganese, Bismuth, etc., are seldom used in the pure state but are employed as alloys and play an important part in developing the physical properties which we expect of metals. The elements which seem to be of prime importance according to our conception of the use of metals are: Iron, Copper, Tin, Zinc, Chromium, Lead, Gold, Platinum, Nickel, Cadmium, Tungsten, Silver and Aluminum. These have been selected as representing the basic

(1) U. S. Department of the Interior, Bureau of Mines Mineral Year Book.

metals which are either used in the pure or commercially pure state, or form the base to which other metals or non-metals are added to produce the alloys of today. Mercury and Radium are important but not as metals. Mercury has a wide usage for indicating temperature because of its range of expansion and contraction associated with small temperature changes. Radium has a decided medicinal value because of the effect of the rays eminating from it, on animal tissue. The various compounds resulting from combinations of different metals with other elements, primary oxygen, are numerous but again their usage is not in line with our conception of metals and therefore, shall not be considered. This is not true, however, of what is termed inter-Metallic compounds such as iron-carbide and other combinations of metals and elements that play an important part in developing the physical characteristics that are important factors when the uses of metals are being considered.

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FOR the sake of orderly presentation, I have classified these factors in three groups.

Economical Consideration
Chemical Behavior
Physical Characteristic

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Economical Consideration
Initial Cost

IN considering the economical factor we must consider not alone the initial cost of the metal but the ultimate cost which combines both the initial cost and the cost of replacement. The initial cost is determined both by the amount and distribution of it in nature and the cost of mining and converting it to its useful state. Examples of the influence on cost of metals resulting from rarity and conversion, may be obtained by comparison of Gold, Aluminum and Iron. Gold is found widely distributed in nature and occurs for the most part in the metallic state, yet the scarcity of it and the limited amount present, per unit weight of earth in any deposit, makes it very costly to obtain. In this case, we have low conversion but a high mining cost. On the other hand, Aluminum is abundantly present in nature but the cost of converting it into the metallic state is high and only the higher percentage deposits are of value. This makes the cost of the metal itself relatively high. Iron is likewise abundantly found in nature and in large enough and rich enough deposits to make it plentiful; yet the costs of converting it to the metallic state is relatively low. This accounts for its low cost. In Table I is also shown the relative cost of metals per avoirdupois pound. No figures were available for Actinium, Virginium, Alabamine, Masurium and Polonium. It is safe to say, however, that they are expensive. A study of this table will reveal a wide range of costs from $.01, the price of the iron blast furnace products commonly known as Pig Iron, to $18,144,000.00, the cost of an avoirdupois pound of Radium. These figures are of course approximate.

TABLE I

Element	1936 price per Avoirdupois lb. $	Element	1936 price per Avoirdupois lb. $
Actinium		Nickel, electrolytic	.35
Alabamine		Osmium	749.34
Aluminum, 99% pure	.205	Palladium	336.59
Antimony, domestic	.1225	Platinum	608.60
Arsenic, metal, lump	.45	Polonium	
Barium	7.50	Potassium	14.00
Beryllium		Radium	18,140,000.00
Sod. Beryllium Fluoride	4.30	Rhenium, metal, powdered	559.80
Bismuth	1.00	Rhodium	1,133.75
Cadmium	.978	Rubidium	1,641.60
Calcium	.75	Ruthenium	553.27
Caesium	453.60	Scandium	
Cerium	25.00	Oxide	2,612.40
Chromium		Selenium	
95%, powder	4.00	Powder	2.00
Cobalt	1.25	Silver	11.86
Columbium		Sodium	.75
Metal	560.00	Strontium	20.00
Copper, electrolytic	.092	Tantalium	68.48
Gallium	680.00	Tellurium	2.00
Germanium	2,494.80	Thallium	15.00
Gold	511.00	Thorium	75.00
Hafnium	680,400.00	Tin	.46
Indium	453.60	Titanium	
Iridium	2,101.16	Metal	20.00
Iron (Com.)	.011	Tungsten	
Lead	.047	Metal	2.25
Lithium	20.00	Uranium	340.00
Masurium		Vanadium	
Magnesium	.30	Metal	567.00
Manganese		Virginium	
Metal	1.00	Yttrium	4,536.00
Mercury	1.05	Zinc	.076
Molybdenum		Zirconium, powdered	6.35
Electrolytic	453.60		

Substitution of Metals

IN many instances, the metals of common use are capable of replacing each other for certain application. Aluminum can be used for some purposes in place of Steel. Copper wire can replace steel wire, etc. In deciding on such substitutions, the initial cost while having an influence is not a deciding factor as much as chemical behavior, physical characteristics and the cost of replacement. Steel is so much stronger than Aluminum that in comparison Aluminum is eliminated from consideration when strength is the important factor. On the other hand where weight is important, as in airplane construction, Aluminum is used successfully in place of Steel. Steel is less expensive to purchase than copper, yet for applications where resistance to weathering is to be considered, it can be proven to be more expensive to employ.

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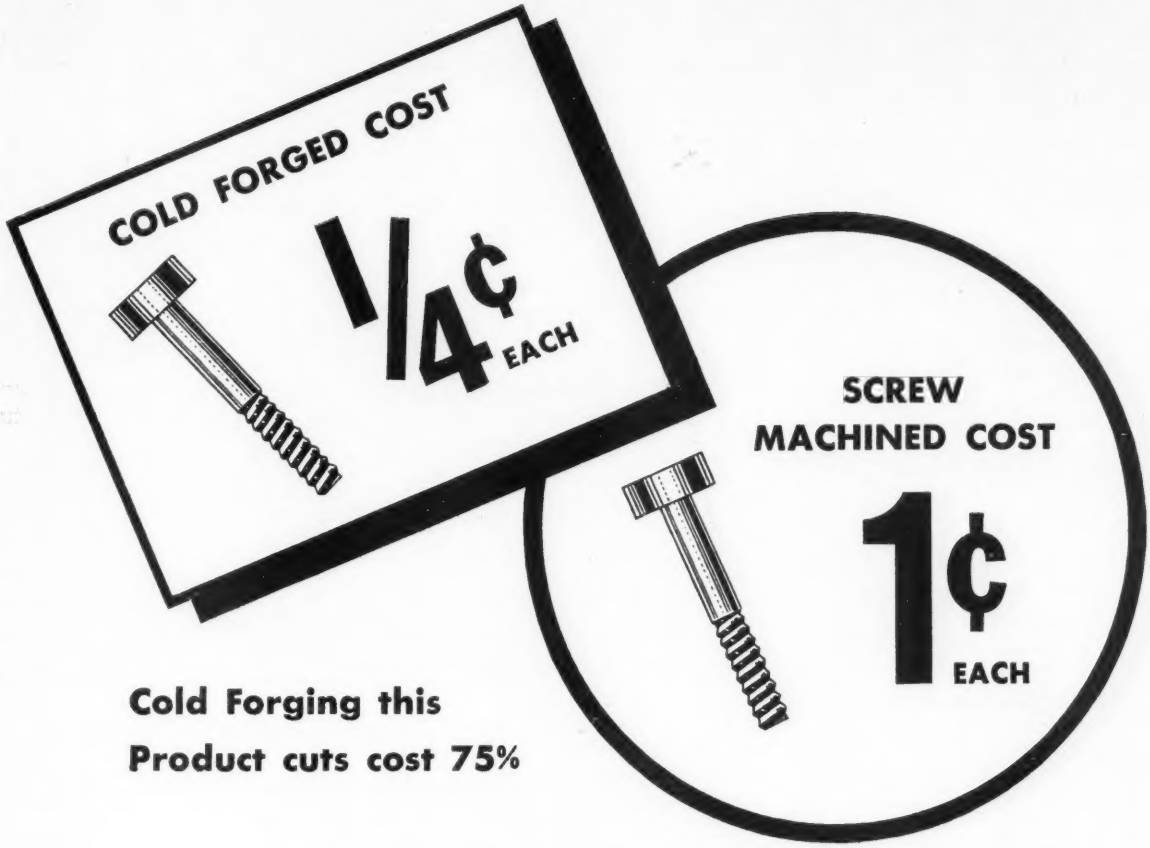
VERY often more expensive metals such as Zinc, Tin,



Cold Forging this Product cuts cost 75%

Too good to be true? Not at all. Modern cold forging is making tremendous savings in the production of more and more small parts. This is only *one* of many examples in *one* of many alert manufacturing plants. Why can't you accomplish savings like this in forming some of your small metal parts? There's a good chance that you can with Manville cold forging machines. Stock economies generally amount to 14%. You will have no scrap at all. Production speed is often boosted 200%-300%. The number of production steps is usually reduced.

Now is the time to be smart in cutting your costs. Let Manville machines help you. The performance of other Manville cold forging machines also warrants your interest. Our Screw Thread Rollers, Bolt Head Trimmers and Screw Slotters are unusually accurate. Get the facts on the entire modern Manville line—and make big savings on small parts.

E. J. MANVILLE MACHINE CO., Waterbury, Conn.

1209 Swetland Building, Cleveland, Ohio

MANVILLE COLD FORGING MACHINES

Chromium, Copper, Gold, Cadmium and Nickel are employed to coat lower priced metals. This may raise the initial cost but the extended life resulting from the protection against corrosion afforded by the coating, may more than justify it.

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CERTAIN elements such as Chromium, Tungsten, Nickel, etc., when alloyed with iron greatly improves the physical properties. Here again the initial cost is higher but the ultimate cost is less because of longer life of the tool or machine parts under consideration.

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APPEARANCES also play an important part and it is often the case where a more expensive metal is employed because it presents a more pleasing appearance. The extensive use of Chromium Plating, Gold, Brass, etc., are examples of this.

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IT is obvious from the above that the economical factor is influenced by the chemical and physical properties of the metal which in turn influence replacement costs.

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Chemical Behavior

Chemical Attractions

THE chemical behavior of metals is traceable to minute balanced charges of electricity called atoms, of which all matter is composed. When a substance is composed entirely of like atoms it is termed an element. Materials which, because of the attraction of unlike atoms for each other, are made up of two or more atoms are termed chemical compounds, because their existance in the combined state depends on the chemical attraction between the atoms of which they are composed. Different atoms display different degrees of attraction for other atoms and contain forces which are not the same. It is this variation in forces and attractions which accounts for the wide variations in the chemical behavior of the elements. Inasmuch as metals are elements, the same hold true, and we have a similar variation in the chemical behavior of metals. In general, the element oxygen has the greatest affinity for metals, however, sulphur, chlorine and other elements also unite freely with them to form chemical compounds. In this way the chemical compounds—Iron-Oxide, Copper Sulphate, Zinc Chloride, etc., of which we are all more or less familiar are formed.

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BECAUSE of a variation in the affinity or degree of attraction of the atoms of some metals for oxygen and other elements there exists a variation in the amount of resistance to chemical attack or corrosion. The resistance of a metal to the formation of chemical compounds with elements present in the atmosphere is an important factor, when one considers the enormous losses encountered each year due to atmospheric corrosion. Some elements offer almost complete resistance to chemical attack. Platinum for example is slow in forming chemical compounds with most elements and because of this, it is used extensively in chemical laboratories. Gold likewise offers considerable resistance to the chemical attack and both these elements offer almost permanent resistance to oxidation at atmospheric temperatures. Iron on the other hand is easily oxidized which tendency is accelerated as the temperature is raised. This factor alone has more to do with the limiting of its use than any other.

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BECAUSE of a variation in rate of chemical attack, metals are often substituted for each other for certain applications. Copper for example dissolves slowly in sulphuric acid and is therefore much more suitable, even though more expensive, for an application such as a yoke in the cleaning of Steel Wire, than steel.

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Influence of Purity

THE maximum resistance to chemical attack of a given metal is associated with its pure state. When another element is added to it, its solubility is immediately increased. It is often the case, however, where two metals which vary widely in solubility will, when alloyed together, produce a metallic alloy which will have a higher resistance to chemical attack than that associated with the metal of greatest solubility. The alloying of Chromium, and sometimes of Chromium and Nickel, with iron to produce the stainless steels and heat resisting alloys of today are examples of this. In this case, the amount of resistance associated with Chromium is sufficient to influence the resistance of the Iron-Chromium alloy and the percentages necessary are low enough to make it commercially practical. It should be remembered however that an appreciable amount of Chromium is necessary in the alloy to create this influence and that there is a point of low-chromium content where the addition of it to Iron will produce an alloy with a lowered resistance to chemical attack than found in either metal in their pure state.

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CHROMIUM in its pure state offers considerable resistance to oxidation. This is shown by the extensive use of chromium plating. The fact that chromium-plated parts have a high "lustre" which persists on long exposures to the atmosphere is proof of this.

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Protective Films

SOME elements, although more soluble generally than others, may, by virtue of the resistance afforded by a film of oxide or other compound, first formed, offer considerable resistance to further chemical attack. Zinc and Aluminum, both of which are more soluble generally than Iron, will, because of a tight oxide film first formed, offer considerable resistance to further oxidation. This is an important factor to consider and accounts for the extensive use of Zinc for the protection of Iron and Steel against atmospheric corrosion.

THE chemical attractions of different elements for each other makes possible the development of numerous alloys. This may take the form of solubility in each other or the formation of intermetallic-compounds which influence physical properties.

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Welding

IN the welding of metals, the chemical behavior is important because of the part that oxidation plays. If a metal is easily oxidized it is difficult to fuse two pieces together without the introduction of oxides. In some metals as in the case of Aluminum, this presents a real problem and it is only recently that the welding of Aluminum was at all possible. To prevent oxidation a protective flux is usually employed and recent developments provide for a reducing atmosphere to combat the formation of oxides.

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IN general, the chemical behavior of metals, whether it be in the formation of alloys or in the resistance to chemical attack or atmospheric corrosion, is a very important factor in connection with the uses of metals. The fact that most metals are found in their natural state in combination with other elements and that there is a constant tendency for them to revert to this original state is an indication of the enormous amount of destructive force of a chemical nature that is continually at work.

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Physical Characteristics

PERHAPS the most important factor which influences the uses of metals is the physical characteristics of the metal itself. Its ability to sustain heavy loads, to withstand abrasion and wear and at the same time its ductility which enables us to form strong tough parts capable of resisting shock. In this connection, the alloys of iron are the most outstanding and regardless of cost or its inability to offer appreciable resistance to chemical attack, iron is still the most valuable metal from a standpoint of use.

THE strength and hardness of the metals most commonly used is shown in Table II.

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TABLE II

Metal	Tensile Strength lbs. per sq. in.	Brinell Hardness Number
Aluminum	30,000	16
Iron	38,000	66
Copper	30,000	48
Cadmium	9,200	20
Gold	20,000	18.5
Chromium	Not listed	350
Lead	1,750	5.5
Platinum	21,000	52
Nickel	75,000	80
Zinc	20,000	35
Tin	5,000	5

THESE values represent the basic strength of the pure metal without cold work or alloys, they can be and often are widely varied by heat treatment, cold working and alloying. For examples, the strength of iron listed as 38,000 lbs. per square inch can be raised to over 200,000 lbs. by the addition of alloys and to over 300,000 lbs. by the additions of alloys and heat treatment. By cold working steel, it is possible to produce a tensile strength of over 400,000 lbs. per square inch. Contrary to expectation, the ductility of the material does not necessarily diminish in proportion to the increase in strength and it is not uncommon to see samples of steel wire with a tensile strength well over 300,000 lbs. per square inch still very ductile.

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COPPER is alloyed with Gold to increase its hardness and resistance to wear and in turn other elements such as Zinc and Phosphorus are alloyed with Copper to produce certain desired properties. Lead, Antimony and Tin are alloyed together to produce suitable bearing metals and so on through numerous alloys both ferrous and non-ferrous all contributing their part in developing the physical properties which our present needs demand of metals.

Metallurgy

THE true story of the use of metals is a story of the development of desired physical properties. Price and chemical attack can be offset but desired physical properties must be developed to suit our needs. In the development of these desired physical properties, the metallurgist has played a most important part and it is with this in mind that I have chosen to provide some of the fundamental principles upon which metallurgy is based. The thought being that by so doing you may become more familiar with what I consider the most important factor in the use of metals.

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ALL metals in the solid state are crystalline. This means that the atoms, of which they are composed, are arranged in some definite geometrical pattern. This accounts for the crystalline fractures, is the ground-work upon which grain size is built and the basis of all consideration in metallurgy. In the original solidification of the metal, this pattern which may be cubic, hexagonal or tetragonal, starts at a number of nuclei and, additional units are added, as the atoms cease the active movement associated with the liquid and become fixed in the solid. This addition of crystal units to a common nucleus, continues in a given area until it encounters resistance to further growth because of contact with units formed from other nuclei. Any group of units starting from a common nucleus form what is commonly termed a grain, and the control of the size and shape of these grains either by rate of cooling or by subsequent heat treatment or cold working constitutes an important part of the metallurgist's work in controlling physical properties. The forces which tend to hold the atoms in a fixed position in the solid state are known as forces of secondary valence. These forces vary in dif-

ferent metals and alloys and account for the variations in physical properties between metals.

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Alloying

WHEN alloys are added to metals, the physical properties resulting may be threefold. They may control the grain size of the metal. They may, by an interchange of the Atoms which compose the crystal units, referred to above, form what can readily be recognized as a new metal, or they can produce precipitated constituents which, because of the interruption of cleavage planes, produce strength. The addition of an alloy to a metal is based on the principle that the alloy is soluble in the metal at some temperature. It does not follow however that the degree of solubility which exists at one temperature persist at a lower temperature. It is very often the case where two metals which are soluble in each other in the liquid-phase are insoluble in the solid-phase. Lead and Antimony are two metals which are soluble in the liquid-phase and insoluble in the solid-phase.

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Precipitation

AS a result of this insolubility a fine precipitate is produced at time of crystallization which changes the characteristics of the metal. Again two metals may be soluble in the liquid phase and partially soluble in the solid phase. As a result of this, we have a solid solution and a precipitated constituent. Two metals or a metal and a non-metal may be joined together by chemical attraction, known as primary valence, to form what is termed an Intermetallic Compound. Iron-Carbide (Fe_3C) and the Antimony-Tin combination (SbSn) are examples of intermetallic compounds which influence the properties of metals. Intermetallic Compounds resemble metals in that they may dissolve in metals and remain soluble in the solid state or they may precipitate out of solution at some temperature and be present in the form of a precipitated constituent. Because of their complex atomic arrangement they are usually harder than the pure metal or solid solution from which they have precipitated. This provides a means of developing alloys which will resist wear and are suitable for cutting tools at the same time the solvent metal from which they have precipitated affords a certain amount of ductility. A large portion of the value obtained by the use of iron is due to the remarkable properties which are produced by a control of the precipitation of iron-carbide.

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WHEN two metals are soluble in each other in the solid state and a solid solution is formed, a new metal having few of the characteristics of the parent metals is often produced. This affords a broad field to work in to obtain physical characteristics to suit our needs. As is often the case, an alloy may consist of more than two elements. It may have two metals completely soluble in each other in the solid state providing a base of desired physical properties and then enhance this quality by the presence of a precipitated Inter-metallic Compound. Alloy steels are examples wherein we have a solid solution resulting from the addition of Nickel, Chromium, Manganese, etc., which produces a strong yet ductile base and precipitated carbides of Iron, Manganese, Chromium, Tungsten, etc., which enables us to produce a wide variety of metals varying in strength hardness and cutting properties. In general, all metals consist of one or more of three prime constituents, namely:

Pure Metals
Solid Solutions
Inter-Metallic Compounds

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Heat Treatment

HEAT treatment plays a very important part in the development of desired physical properties in metals by controlling grain sizes and precipitation. Because of a degree of solubility which exists between carbides and iron at high temperatures remarkable physical properties can be developed by heating the ferrous alloys to a temperature at which the carbide is soluble followed by controlled cooling. If the rate of cooling is sufficiently fast the temperature can be reduced at a rate which will prevent precipitation. This provides an unstable solid solution and by subsequent reheating the carbides are precipitated with a maximum degree of fineness which will greatly increase the hardness yet, at the same time, the solid solution matrix will provide a reasonable amount of ductility. It is in this manner that the remarkable properties of tool steels are developed.

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EVEN with a lesser speed of cooling, not sufficient to prevent precipitation, the size of the precipitated carbides can be controlled to suit certain purposes.

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HEAT treatment is employed in developing physical properties in non-ferrous alloys as well as ferrous alloys. Outstanding in this group is the copper-beryllium alloy wherein the metal is cooled suddenly to retain solubility followed by heating to 400°F to 800°F to cause precipitation. In this manner a copper base metal of considerable hardness is developed.

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Metallography

WHEN examined under the microscope, the structure of the metals reveals to some extent the physical properties. Grain size can be measured and the size and shape of the precipitated constituents determined. In this way suitable treatments can be developed which will bring out the maximum properties.

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IN figures 1 to 9 are shown photomicrographs of different structures. Figure 1 is of a pure metal (Nickel) and shows the grains referred to above. Figure 2 shows a solid solution of (Chrom-

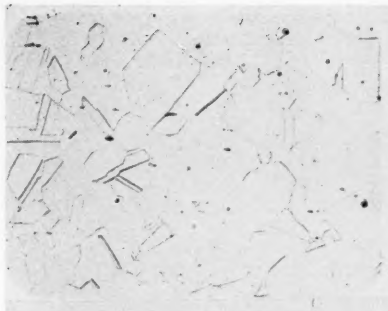

Fig. 1. Pure Nickel - 100 X.

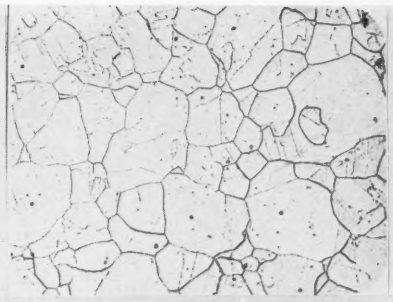

Fig. 2. Solid Solution of Chromium & Nickel in Iron (Austenite) 100 X. * *

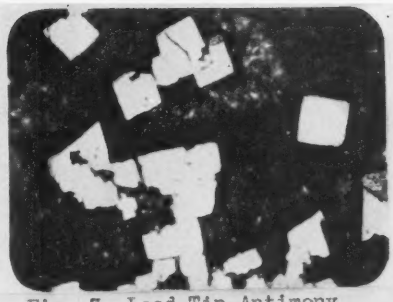

Fig. 3. Lead-Tin-Antimony bearing metal, showing precipitated particles of Antimony-Tin Compound (white constituent) - 1000 X. *

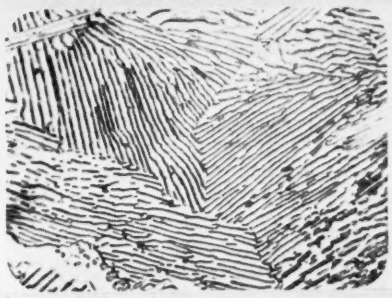

Fig. 4. Structure of Pearlite showing alternate plates of Iron (Ferrite) and Iron Carbide (Cementite) - 2000 X. *

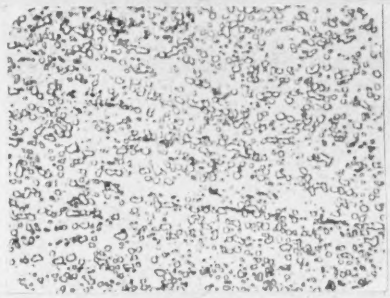

Fig. 5. Spheroidized structure showing type of Carbide particle wherein the Iron Carbide (Cementite) occurs in rounded particles - 1000 X. * * *

Fig. 6. Structure of Martensite. Rate of cooling has been fast enough to prevent Carbide precipitation - 2000 X. * * *

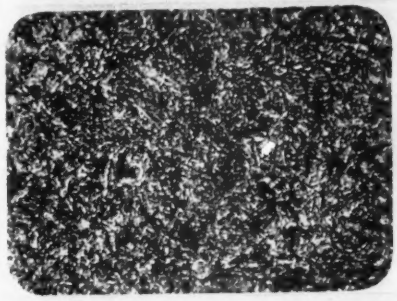

Fig. 7. Same as figure 6 after heating to 900°F. Note how precipitation has occurred but in very fine particles - 2000 X.

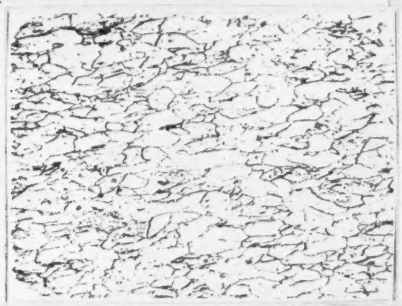

Fig. 8. Low Carbon Steel after Cold Working - 200 X. * *

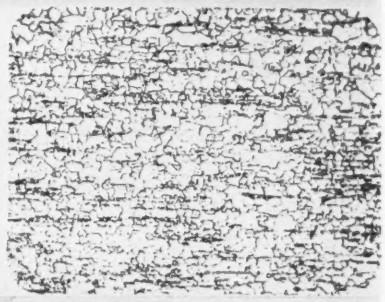

Fig. 9. Same as figure 8 after heating above its recrystallization point. - 200 X. * *

ium and Nickel in Iron) note the resemblance between these two. In neither case have we a precipitated constituent. In figure 3 is shown the structure of a lead-tin-antimony bearing metal. The precipitated particles here shown (white constituent) is that of the Antimony-Tin Compound SbSn. In figure 4 is shown the structure of pearlite which consists of alternate plates of Iron (Ferrite) and Iron-Carbide (Cementite). In figure 5 is shown another type of Carbide particle wherein the Iron-Carbide (Metallographically called Cementite) occurs in rounded particles. In figure 6 is shown the structure termed Martensite wherein the cooling has been fast enough to prevent Carbide precipitation. In figure 7 is shown the same sample after heating to 900°F. Note how precipitation has occurred but in very fine particles. In figure 8 is shown a sample of steel wire which has been cold worked while in figure 9 we have the same sample after heating above its recrystallization point.

NOTE how the elongated grains are replaced by equiaxed grains as a result of this treatment.

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Resistance to Deformation

THE size and arrangement of the atoms in a pure metal determines the amount of movement or distortion that it can undergo without fracture also the amount of resistance to deformation or strength present. This property is a constant for any given metal in

(*Please turn to Page 205*)

Westphal Becomes President of The Wire Association

At the Annual Directors Meeting of the Wire Association held in New York, N. Y., March 18, 1938, officers were elected and general plans for the 1938 meeting discussed. A digest of the conclusions reached is presented. ✦ ✦ ✦ ✦ ✦

THE Annual Meeting of the Board of Directors of the Wire Association was held at the Waldorf-Astoria Hotel, New York, N. Y., at 10:30 A. M. on March 18, 1938.

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THE meeting was called to order by Ralph K. Clifford, General Works Manager, Continental Steel Corp., Kokomo, Indiana, president of the Wire Association presiding, and eleven of the fourteen directors, constituting a quorum, were present.

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THE Secretary read the minutes of the previous Directors' Meeting and presented the financial report for the year ending March 1, 1938. Both were ordered approved and entered upon the minutes.

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UNDER the heading of unfinished business a proposal presented at the last meeting to enter into a contract with WIRE AND WIRE PRODUCTS for a period of years to effectuate the intent of Article 6 of the By-laws of the Association was taken up, and it was voted unanimously to enter into such a contract at this time. The details of the contract were left to a committee elected by the board with instructions to proceed with the necessary arrangements.

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Election of Officers

THE Nominating Committee, consisting of Messrs. Pierson, Lewis and Brown, unanimously submitted the following nominations for officers for the year 1938:

President—F. A. Westphal
Vice President—John C. Callaghan
Vice President—E. W. Clark.
Secretary and Treasurer—Richard E. Brown

IN submitting the nominations the Committee pointed out that an attempt was being made to set up a precedent under which the vice president of the ferrous division would normally succeed as president upon the expiration of the previous incumbent's term.

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THE report of the Committee was unanimously approved and the Secretary was instructed to cast one ballot for the election of these officers.

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MR. Ralph K. Clifford, the retiring president, now becomes past president with the privilege of attending and discussing all matters at all board meetings in that capacity.

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MR. Frederick A. Westphal, Supt. of Wire Mills, Sheffield Steel Co., Kansas City, Mo., the incoming President in a short address of acceptance said:-

THE honor bestowed upon me as your newly elected President means to me that I sincerely trust and hope that there will be a continuance of the high standards of performance already in effect. I approach this work with a high sense of duty and an earnest desire of continued cooperative action and harmony.

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MY predecessor Mr. Ralph Clifford, of Continental Steel Co., has given a very worthy administration of affairs these past two years and it is hoped that I may perform and administer with as good judgment and tact.

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IT is a pleasure for us to realize the reelection of Mr. Clark of the General Electric Co. as a director for another term and also his reelection as Vice-President of the Non-Ferrous Section that he has handled in the past so efficiently. It is also pleasing to us to announce the election of Mr. John Callaghan of the Steel Company of Canada as my successor as Vice-President of the Ferrous Section. He has performed so nobly for us in the past as chairman of the Program Committee and indeed his wise words of counsel shall continue to be of value to us all.

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WE heartily welcome the election of our new directors Messrs. Bassett of Anaconda Wire and Cable Co., Beeson of the Pittsburgh Steel Co., Harrison of the Atlantic Steel Co. It is fitting to state that we regret seeing Mr. Barningham of New England Butt Co. leaving the board of directors after so many years of faithful service to the Association.

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IT is appropriate at this time of the Annual Directors Meeting to express the gratitude and appreciation for the fine services that Major Brown has so generously given us. In the past years, unquestionably he has been a real wheelhorse in this outfit in every sense of the word and we are happy to announce that we shall make provisions to ensure the fine work he has performed as our Secretary of this Wire Association combined with publishing our official organ, namely WIRE & WIRE PRODUCTS.

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IT is especially interesting to realize that we have quite a number of foreign members that truly give us an international aspect, and at our Convention it is a pleasure to meet with our fellow members from Europe, Australia, Asia and other parts of the world. Let us hope that we can continue with our annual increase of membership.

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IN conclusion I pledge my best efforts in the behalf of the Wire Association, and whatever trials, tribulations or obstacles that may arise that we shall meet them successfully, constructively and progressively. I thank you.

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Registration Fee and Proceedings

IT was voted to continue the present registration fee of $5.00 for those attending the convention, but because of the increased cost involved in having the proceedings prepared in separate form, it was voted to have the Proceedings and discussions published in WIRE

AND WIRE PRODUCTS in the two or three issues immediately following the convention. This the publisher of WIRE AND WIRE PRODUCTS agreed to do. In this connection it was decided that prior to the publication of the Proceedings each member participating in the discussion should be afforded an opportunity to edit his remarks before publishing.

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Medal Award

THE Medal Award will again be made at the annual meeting of the Association on Wednesday afternoon of the Convention week.

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Regional Meetings

IN view of the success of last year's regional meeting and the satisfactory working out of the plans for the 1938 Pittsburgh Regional Meeting, it was definitely decided to continue and develop such activities.

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1938 Convention

THE selection of the Detroit-Leland Hotel by the officers of the Association as Convention headquarters for the 1938 Meeting which will be held at Detroit, October 17th to 21st, was ratified by unanimous vote of the Board of Directors.

Program Committee

MR. LeRoy D. Seymour, Metallurgist, Rod and Wire Division, Youngstown Sheet & Tube Co., Youngstown, O., was elected chairman of the Program Committee for the 1938 meeting, and in this connection the Secretary advised that he already had five papers submitted for consideration for the meeting.

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McCarthy Lectures

AT the 1938 meeting, Mr. B. L. McCarthy, Chief Metallurgist, Wickwire Spencer Steel Co., Buffalo, N. Y., will deliver a series of three lectures outlining the background of metallurgy as it applies to the wire industry. These lectures will be in simple language, understandable by the non-metallurgist, and the titles are tentatively:

1. **Critical Points of Metals**
2. **Thermal Reactions of Metals**
3. **Cold Working of Metals**

All registered members of the Association will be entitled to attend these lectures without any additional cost.

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British Visitors Invited to 1938 Sessions

IT was unanimously voted that in view of the fact that the British Institute of Metals and the British Iron and Steel Institute are going to attend the American Society for Metals Meeting this year that the Wire Association extend an invitation to the members of these European visiting societies to attend any and all of our sessions on a guest basis without payment of our registration fee. The Secretary was instructed to extend this invitation to the proper officials of those societies by letter.

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Plant Inspection

THE Secretary placed before the Board the thought that since the Carboloy Company was building a new plant in the vicinity of Detroit it would be an excellent idea to invite that company to hold a plant inspection as a part of our Convention proceedings. The Secretary pointed out that at the present time, there was no definite date set for the completion of the plant but that such an invitation should be extended to the Carboloy Company and left open in the event of their plant being ready. The Board unanimously approved this idea and authorized the Secretary to extend such an invitation to the Carboloy Company.

Outstanding Personalities of the Wire Industry

J. C. Foster, President Northwestern Barb Wire Company

ANNOUNCEMENT of his election to the Presidency of the Northwestern Barb Wire Company, of Sterling, Illinois, was made March 1, 1938 by James Caven Foster, together with his resignation as general manager of sales of the Jones & Laughlin Steel Corporation.

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THE selection of the Detroit-Company, founded in 1879, manufactures a full line of wire products from electric steel, having an annual capacity in all lines of finished products of approximately 350,000 tons. Until Mr. Foster's election, Paul W. Dillon held the office of President as well as Chairman of the Board.

J. C. FOSTER,
President, Northwestern Barb Wire Co.

✦ ✦ ✦

MR. Foster's entire business experience has been with Jones & Laughlin. He went to work in 1913 in the order department and two years later was transferred to the sales department, where he remained continuously excepting for the period of his service in the American Expeditionary Forces during the World War. He was made manager of Wire Sales in 1932 and general manager of sales in 1935.

✦ ✦ ✦

C. B. Patt, Superintendent Allentown Works, American Steel & Wire Co.

CHARLES B. Patt, Assistant Superintendent at the Donora, Penna., Works of American Steel

(*Please turn to Page 212*)

Exports and Imports of Wire

Exports of Iron and Steel Wire Products in Jan. 1938 and Jan. 1937
(In Gross Tons)

	JAN. 1938	DEC. 1937	JAN. 1937
Wire rods	2,488	2,811	3,279
Strip steel	5,963	8,453	8,410
Plain, black or galvanized iron or steel wire	3,559	3,183	4,200
Barbed wire and woven wire fencing	965	1,987	3,523
Woven wire screen cloth	69	106	126
Wire rope	305	529	215
Insulated iron or steel wire and cable—see analysis below			
Other wire and manufactures	502	529	539
Wire nails	825	1,678	1,087
Tacks	10	33	23
Other nails, including staples	145	327	203
Bolts, machine screws, nuts, rivets and washers	700	744	698
Total, these 11 classifications	15,531	20,380	22,303

Imports of Iron and Steel Wire Into the United States
(In Gross Tons)

Concrete reinforcement bars	45	85	772
Hollow bar and drill steel	125	191	164
Wire rods	504	634	1,626
Barbed wire	3,242	589	1,585
Round iron and steel wire	73	484	325
Telephone and telegraph wire	.....	17	6
Flat wire and strip steel	263	262	282
Wire rope and strand	213	232	227
Other wire	259	65	278
Hoops and bands	2,177	1,878	2,141
Nails, tacks and staples	536	432	1,171
Bolts, nuts and rivets	12	9	24
Total, these 12 classifications	7,449	4,878	8,601

Exports of Insulated Wire and Cable, January, 1938

	Foreign		To U. S. Possessions	
	Pounds	Dollars	Pounds	Dollars
Rubber-covered wire	425,093	$110,686	66,859	$ 6,158
Copper weatherproof wire	97,041	19,365	14,389	2,672
Other insulated copper wire	666,800	134,079	60,369	12,580
Nickel-chrome electric resistance wire	17,629	22,049	.....	.....
Total, these 4 classifications	1,206,563	$286,179	141,617	$21,410

Ingots, Pig Iron, and Plate Outstanding

THE outstanding products exported in January (from a tonnage standpoint) continued to be those which attained the highest totals in 1937. Steel ingot shipments amounted to 37,639 tons and went mostly to the United Kingdom (19,636 tons), and Japan (16,566 tons). Next-ranking were pig iron shipments (35,997 tons) going principally to the United Kingdom (18,660 tons), Japan (14,916 tons), and Sweden (1,103 tons). Following came plate (boiler, fabricated, and 'other') in a widespread trade totaling 27,453 tons, the outstanding outlets being the Netherlands (5,601 tons), Sweden (5,159 tons), Japan (4,578 tons), Kwantung (4,221 tons), and Canada (2,427 tons). Fourth in importance was tin plate (19,073 tons) reaching many markets, of which the outstanding ones were Turkey (3,424 tons), Japan (2,011 tons), and Brazil (1,923 tons), Argentina (1,283 tons), and British India (1,175 tons). Next was the steel bar total of 19,047 tons, the ranking markets being the United Kingdom (5,667 tons), Kwantung (3,233 tons), Canada (1,906 tons), and Japan (1,231 tons). Then came black steel sheets with 17,520 tons going principally to Canada (4,328 tons), the Soviet Union (3,114 tons), Australia (1,961 tons), and Mexico (1,290 tons). Rail shipments amounted to 13,174 tons and were practically all taken by Kwantung (8,072 tons), and Chile (4,022 tons).

Where January Shipments Went

FOR the third consecutive month, the United Kingdom in January was the leading individual market, its 49,246-tons total consisting of mostly steel ingots (19,636 tons), pig iron (18,660 tons), and steel bars (5,667 tons). Japan was next with 42,844 tons of mostly ingots (16,566 tons), pig iron (14,916 tons), plate (4,397 tons), and tin plate (2,011 tons). Shipments to Kwantung continued high when they totaled 21,986 tons, the outstanding products being rails (8,072 tons), plate (4,221 tons), shapes (3,690 tons), steel bars (3,223 tons), and tin plate (1,132 tons). Canada ranked fourth with 18,878 tons in a widespread trade in which the outstanding items were black steel sheets (4,328 tons), strip steel (3,079 tons), plate (2,427 tons), shapes (2,419 tons), and steel bars (1,906 tons). Venezuela took 8,134 tons of mostly seamless casing and oil-line pipe (3,034 tons), and shapes (2,430 tons). Shipments to the Netherlands amounted to 7,599 tons and were mostly plate (5,601 tons), and tin plate (951 tons). Chile took 7,470 tons of principally rails (4,022 tons), and ingots (456 tons).

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Pig Iron Leading Import Item

PIG iron remained the outstanding product imported on a tonnage basis, its total of 9,747 tons comparing with 9,128 tons in the preceding month and with 12,434 tons in January 1937. The outstanding suppliers during the reviewed month were British India (5,491 tons), and the Netherlands (4,160 tons). Following came steel pipe whose 5,061-ton total compared with 2,884 tons and 724 tons, and came mostly from Germany (4,596 tons), and Sweden (296 tons). Barbed wire ranked next with 3,242 tons against 589 tons and 1,585 tons, and came principally from Germany (2,987 tons), and Belgium (216 tons). Then came shapes in a 3,147-ton trade which compared with 3,396 tons and 7,919 tons, the bulk coming from Belgium (2,522 tons), and France (529 tons). Hoops and

bands followed with 2,196 tons against 1,878 tons and 2,141 tons, and originated mostly in Belgium (2,038 tons), and France (123 tons). Steel bars ranked next with 1,899 tons against 2,547 tons and 5,876 tons, the leading sources being Belgium (1,267 tons), Sweden (382 tons), and Germany (140 tons).

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Highest Volume From Germany

AFTER trailing Belgium for a number of months, Germany ranked as the leading source of the January import trade and accounted for 8,717 tons in comparison with 3,907 tons in the previous month and 3,063 tons in the corresponding one of 1937. The outstanding products in this trade were steel pipe (4,596 tons), barbed wire (2,987 tons), and nails, tacks, and staples (517 tons). Belgium ranked second with a 6,894-ton total against 7,134 tons and 14,588 tons, the predominating products being shapes (2,522 tons) hoops and bands (2,038 tons), and steel bars (1,267 tons). British India accounted for 5,491 tons against 5,460 tons and 5,404 tons, and pig iron was the only product in this trade. Then came the Netherlands with 4,313 tons against 2,671 tons and 5,091 tons, with pig iron (4,160 tons) by far the outstanding item. Sweden accounted for 1,928 tons against 3,010 tons and 3,107 tons of mostly wire rods (483 tons), steel bars (382 tons), steel pipe (296 tons), flat wire and steel strips (235 tons), and billets (231 tons).

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CARD CLOTHING imports amounted to 23,422 square feet valued at $34,514 against 24,403 square feet valued at $43,562 and came from the United Kingdom (16,114 square feet valued at $28,367), Belgium (6,690 square feet valued at $5,027), and Germany (618 square feet valued at $1,120).

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IMPORTS of WIRE HEDDLES at 1,053,000 pieces compared with 227,000 pieces and came from Germany (600,000) and Japan (453,000).

RECEIPTS of WIRE FENCING AND NETTING of the galvanized before weaving grade amounted to 907,000 square feet and came from Belgium (744,500), and the Netherlands (162,500). Of that galvanized after weaving, the total was 1,236,100 square feet against 355,600 square feet, the supplying countries being Germany (613,600), the Netherlands (411,000), and Belgium (211,500).

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THE trade in WIRE CLOTH AND SCREEN totaled 52,363 square feet against 61,248 square feet, and was covered by Germany (32,446), Canada (14,618), the Netherlands (3,862), Austria (737), and Japan (700).

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FOURDRINIER AND OTHER PAPER-MAKING WIRE imports amounted to 29,618 square feet against 23,938 square feet and were received from Austria (12,437), Sweden (9,373), Germany (6,388), and France (1,420).

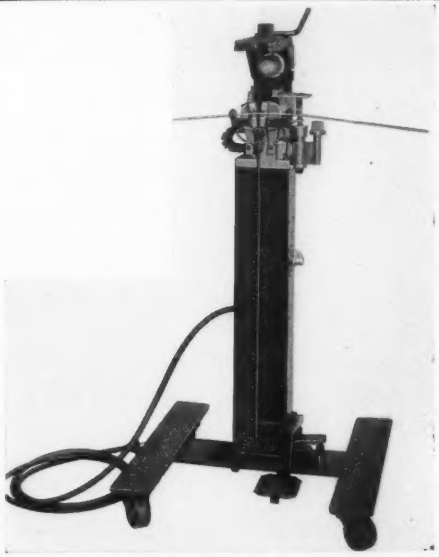
(*Please turn to Page 213*)

MICROMETER PRECISION MICRO-WELD TRADE MARK REG. U. S. PAT. OFF.

CONTINUOUS IMPROVEMENT

MICRO-WELDERS with dial indicating annealing attachments are now available for high carbon wire.

There is positive control of annealing temperature and already hundreds of these special MICRO-WELDERS are proving their dependability and satisfactory performance with leading manufacturers.



MICRO PRODUCTS COMPANY
20 NORTH WACKER DRIVE, CHICAGO, ILL.
Telephone State 7468

'Round the World With the Wire Industry

Agreement Between International Steel Cartel and Norwegian Importers

THE International Steel Cartel is reported to have entered into an agreement with a group of leading *Norwegian* importers whereby those importers will purchase exclusively from rolling mills located in countries which are members of the cartel, advises the American Consulate General, Oslo. Until very recently, steel ship material was omitted from the agreement, but it appears that it will now be included in addition to such other items as steel wire, thin sheets (black and galvanized) and hoops (black and galvanized).

Blankets COSTS, *too!*

A SCIENTIFICALLY PREPARED DRY BLANKET COVERING FOR MOLTEN METAL BATHS OF ZINC, LEAD, TIN AND THEIR ALLOYS

The very fact that this *NEW* preparation has proved economical in its every application, should well warrant its trial on your galvanizing baths. Astonishing savings in costs and labor rank it paramount in its field. G. B. 412 GALVANIZERS' BLANKET *prevents loss of heat by radiation ... Saves 35% to 50% of fuel ... Prevents oxide formation ... Is safe to handle* and *Easily applied.*

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FORTY YEARS OF SUCCESSFUL SERVICE

Steel Prices to Be Maintained by The International Steel Association

FROM the office of the American Consulate, Strasbourg, France, comes word that the Joint Coordination Committee of the *International* Steel Association meeting at Dusseldorf decided to maintain the present prices for steel products. Comments on the agreements made at the meeting include:

(1) That while prices were agreed upon, the American manufacturers were not limited to any quota or tonnage that might be delivered at the prices named;

(2) That the agreements include only the larger manufacturers and do not in any way control smaller organizations;

(3) That American participation in European markets will depend on the home market and if the home market improves the pressure of American exports will be relieved;

(4) That the "Americans" are "new on the European market" and no one is sure just how binding the agreements will be on the "Americans" if the economic situation shows evidence of change.

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IT is stated to have been frankly admitted that the conference at Dusseldorf was for the purpose of curtailing shipments of American "steel" to the European market.

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German Notes

THE IWECO denies reports that prices have been cut by 15 to 20 shillings per ton. Prices were reduced 7/6 to 12/6 shillings on all wire products in a few markets only. These were principally Central America, the West Indies and all Far Eastern markets. The quotations to all others are unaltered. The general demand for wire products has not yet materially improved. Some markets—the Balk-

ans and the Near East for example —are buying more; in all other markets, however, business is rather quiet. It is expected that the January and February 1938 export figures will be below those for 1937. This applies also to special grades of wire products.

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German Wire Rod Production

GERMAN wire rod production in 1937 was 1,208,032 tons—a new high mark. December production was a new record reaching 112,630 tons. The output was nearly 20% more than in 1936. Germany exported 63,280 tons and imported 38,450 tons. Total wire production including wire nails and all other wire products was 1,083,100 tons, which is 21% over 1936.

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FREIGHT rates for cables and other electric wire from Germany to Holland and some other neighboring countries have been reduced.

German Exports and Imports

TOTAL exports of wire excluding nails and other wire products) from Germany in 1937 were 239,735 tons and the value 45.6 Million Marks as compared with 32.6 Million Marks in 1936. Total imports were 10,676 tons valued at 3.4 as compared with 2.7 Millions in the year before.

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THE official price for wire rods in Germany has not yet been reduced (except the 10 shilling reduction in January). However, the international wire cartel is selling wire rods upon demand up to 17/6 shillings below the former official quotations. The demand for S.M. wire rods has decreased and the extras were reduced to 8 shillings Wire rods in large and heavy coils are still in satisfactory demand.

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THE German wire industry for the first time since the beginning of 1937 has obtained in January the full 100% appropriation of raw materials. This corresponds to the demand of 1936 and as the actual demand exceeds that of 1936, the wire industry is trying to get higher allotments and it is probable that more raw material will be supplied to the wire makers beginning with March.

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PORCELAIN as a new insulating and protecting material for electric wires and cables is gaining further favor in Germany and is particularly used as tubes in house laying of wires. It has been standardized and Standards were issued for all purposes.

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GERMAN exporters report that the Chinese boycott against Japanese wire products wherever Chinese merchants are doing business has led to a great upturn for the Indian merchant, particularly in the Straits, the South Sea, the Philippines, West Indies etc. as the Indian merchant is not participating in the boycott movement. Business is therefore shifting from the hands of the Chinese dealer to the Indian.

(*Please turn to Page 200*)

GLADER WIRE NAIL MACHINERY

The Glader Nail Machine of today is the result of forty years experience in the building of wire nail machines.

Glader machines are made in ten different sizes, to cover most efficiently, any size of nails.

The production on these machines ranges from 160 nails per minute, made from 3/8" wire 12" long, to 700 nails per minute made from 16 gauge wire 1-1/8" long.

Write for our catalogue and make your own comparison of our guaranteed production figures with what your present equipment is producing.

For further information address,

WM. GLADER MACHINE WORKS

210 N. RACINE AVENUE

CHICAGO, ILLINOIS.

'Round the World With the Wire Industry

(*Continued from Page 199*)

German Utilization of Low Grade Iron Ore

A NEW and outstanding feature of **Germany's** self-sufficiency drive (which did not form a part of the original plan as proclaimed in the fall of 1936) was the announcement, in August 1937, of the formation of a special company, the "Hermann Goering Reich Iron Works" for the exploitation of Germany's low-grade iron ore, reports the office of the American Commercial Attache, Berlin. This project was no doubt stimulated by the shortage of iron and steel which became acute by the middle of 1937, and necessitated drastic measures for the economizing and rationing of supplies. It has been officially estimated that 26,000,000 metric tons of steel ingots would be necessary to cover Germany's annual requirements at the present rate of industrial and construction activity. The total domestic production did not exceed 19,700,000 tons in 1937. The object of the new company is to produce about 6,000,000 tons of pig iron annually from low-grade ores in the Salzgitter district (near Brunswick), Franconia, and Baden. The scheme involves not only the sinking of shafts but also the construction of iron and steel plants and rolling mills. The Salzgitter district is the first to be developed and construction work is already in full swing.

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German Substitute for Copper Tubes

A FIRM in the Southwest area of **Germany** is reported to have been successful in producing (by a new process) a type of corrosion-proof steel tubes that is said to be an acceptable substitute for copper and brass tubes, advises the American Consulate General, Frankfort-on-Main. The principal objective behind this new development is stated to be in the considerable saving of copper which the new process enables, since Germany is dependent upon imports for nearly all of its copper requirements.

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Silicon Bronze Wire Reduces Plane Static

THE commercial airlines have been experimenting with a 6-section, 7-strand, silicon bronze rope made of .0071 size wire, known as aircraft antennae cable, and have found it to be exceptionally durable for use as static discharge cables on airplanes. The wire trails from the wings, relieving the metal body of static which before development of the cable had interferred with necessary 2-way radio communication.

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THE speed of airplanes subjects these wires, the outside diameter of which is only 1/16-inch, to violent whipping action while a flight is in progress. Because of the relative long life of this silicon bronze rope its use for this purpose has met with considerable success.

THE WATSON MACHINE COMPANY

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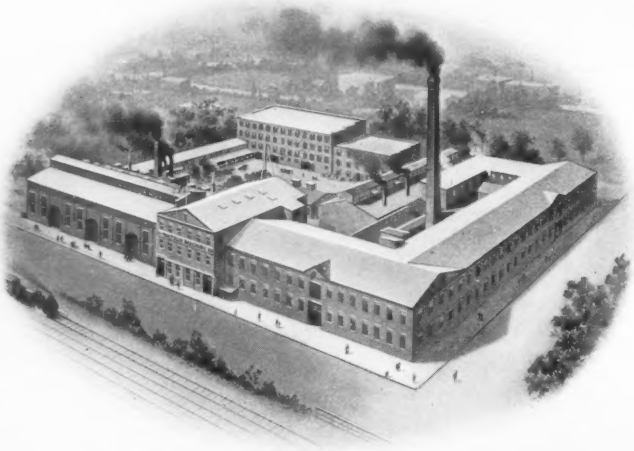

ENGINEERS MACHINISTS

MANUFACTURERS OF

ELECTRICAL WIRE & CABLE, WIRE ROPE, CORDAGE & GENERAL MACHINERY

YOUR INQUIRIES ARE INVITED

A Review of Recent Wire Patents

No. 2,105,102, WARP FEED FOR WIRE WEAVING LOOMS, Patented January 11, 1938 by Herbert L. Thompson, Elgin, Ill., assignor to Reynolds Wire Co., Dixon, Ill., a corporation of Ill.

Warp wire feeding and tensioning means is provided for a wire weaving loom such as disclosed in the inventors' patent 2,022,225, an object being to provide a feed by which warp wires can be supplied in identical lengths to the loom. Means for holding the warp wires in place in splicing a broken wire is provided.

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No. 2,105,105, MACHINE FOR ELECTRICALLY HEATING SPRINGS, Patented January 11, 1938 by Fred R. Zimmerman, Chicago, Ill., assignor to Nachman Spring-Filled Corporation, Chicago, Ill., a corporation of Illinois.

This machine comprises a rotating carrier equipped with receptacles each adapted to receive a spring, which is partially compressed at a predetermined point of travel of the carrier, after which an electrical connection is made and maintained during a predetermined arc of travel of the carrier, the springs being discharged successively from the receptacles upon completion of a revolution of the carrier.

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No. 2,105,115, UPHOLSTERY SPRING ASSEMBLY, Patented January 11, 1938 by William W. Gleason, Chicago, Ill., assignor to Nachman Spring-Filled Corporation, Chicago, Ill., a corporation of Illinois.

A group of interconnected springs is formed into a rectangular structure having corners which are re-inforced by strips of thin sheet metal folded into U-shaped cross-section and bent between the ends of a curvature coinciding with that of the terminal coils of the corner springs. In a modified construction, the corner reinforcements are of looped wire.

✦ ✦ ✦

No. 2,105,168, ELECTRIC CABLE, Patented January 11, 1938 by Horace A. Staples, Plainfield, N. J., assignor to Phelps Dodge Copper Products Corporation, New York, N. Y., a corporation of Delaware.

In this coaxial two-conductor cable, the interposed insulation consists of a layer of rubber and a bedding for the outer conductor, which latter is formed from a continuous tape spirally wrapped in a plurality of layers with a longitudinal seam.

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No. 2,105,338, ROPE MAKING MACHINE Patented January 11, 1938 by Charles C. Sunderland, Trenton, N. J., assignor to John A. Roebling's Sons Company, Trenton, N. J., a corporation of New Jersey.

At the head of the rope-closing machine, a mandrel or forming core is employed, around which the strands are wound in laying them up to form a rope while the strands are under mandrel tension, all strands being wrapped around the same mandrel, so as to secure a uniform tension on the strands, which is readily adjustable. An internal mandrel with helical grooves is employed to determine the helical curve of the strands just prior to or in closing.

Complete Descriptions and Drawings of Patents May Be Had for 25 cents. Address, Wire & Wire Products, 17 East 42nd St., New York.

✦ ✦ ✦

No. 2,105,812, BEAD WIRE DIE, Patented January 18, 1938 by John T. Gordon and Robert W. Snyder, Akron, Ohio, assignors to Wingfoot Corporation, Wilmington, Del., a corporation of Delaware.

Rubber under pressure is extruded through the die to coat the bead wires individually prior to coating a group of wires as a unit, the wire being properly aligned as it passes through the die to insure a uniform coating. The die is so arranged as to be quickly disassembled for cleaning.

✦ ✦ ✦

No. 2,106,048, CODED WIRE, Patented January 18, 1938 by Albert T.

(Please turn to Page 202)

SEVEN ECONOMICAL REASONS
WHY

STEVENS FLANGED STEEL DRUMS

Are Used

ASK A USER

WRITE FOR DETAILS

(1) Reduce reel assembly costs by eliminating the labor of handling a large number of small parts.

(2) Make a stronger reel.

(3) Increase number of trips per reel from 50 to 100% before cut downs or complete scrapping of wooden reel heads.

(4) Drums can be used over and over.

(5) Reduce maintenance cost.

(6) Reduce potential hazard of damage to wire and cable in transit and in field.

(7) Have given over eleven years service without refinishing or major maintenance.

These statements are taken from actual experience records.

STEVENS METAL PRODUCTS CO.
NILES, OHIO

A Review of Recent Wire Patents

Candy, Jr., Oak Park, Ill., assignor to Candy & Company, Inc., Chicago, Ill., a corporation of Illinois.

In order to provide a code whereby a large number of distinguishable combinations is possible, a plurality of outer color coatings is provided, so that the number of different colors may be limited to a few readily distinguished colors. The method of coding and identifying the individual conductors includes scraping off regions of the outer color coating so as to reveal the color of the under coatings and yet not impair the insulation.

No. 2,106,060, ELECTRIC CABLE, Patented January 18, 1938 by John K. Ostrander, Philadelphia, Pa.

Formed in encircling spaced relation about a rubber-insulated conductor or core, is an outer layer of spiral wires, of hard steel and soft copper alternately. This outer layer is then compressed so that the steel wires bite into the adjacent copper wires and hold the same under compression.

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No. 2,106,437, MACHINE FOR COVERING WIRE WITH A HELICAL WRAPPING, Patented January 25, 1938 by Alexander John Sands, Westminster, London, England, assignor to The London Electric Wire Company and Smiths Limited, London, England, a corporation of Great Britain.

Paper, cellulose cotton, wool or silk in ribbon form may constitute the insulative wrapping and the machine employed is one in which a wire to be wrapped is continuously drawn through the center of a rotary head arranged to rotate about the axis of the wire and carrying a supply of the material which is wrapped helically about the wire, with the tension maintained substantially constant throughout the wrapping operation.

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No. 2.106,454, WIRE COILING AND INTERWEAVING MECHANISM, Patented January 25, 1938 by Parmenas F. Frost, Mount Vernon, N. Y., and John C. Anderson, Keyport, N. J.

With the mechanism described, the angle at which the wire is coiled can be increased beyond the usual maximum, to form netting which may consist of diamond-shaped portions having interior angles of 60° and 120°. The forming die includes a groove which, throughout most of its length, is of relatively wide angularity, but is of a different angularity at the entrance portion.

✦ ✦ ✦

No. 2,106,644, FRAME AND SEAT, Patented January 25, 1938 by Clarence H. Menge, Detroit, Mich., assignor to The Murray Corporation of America, a corporation of Delaware.

Flat ribbon springs formed of zig-zag wire are employed in lieu of coil springs in this seat and the frame is made up of grooved sections in which an end of the spring unit is secured by deforming the metal defining the groove.

✦ ✦ ✦

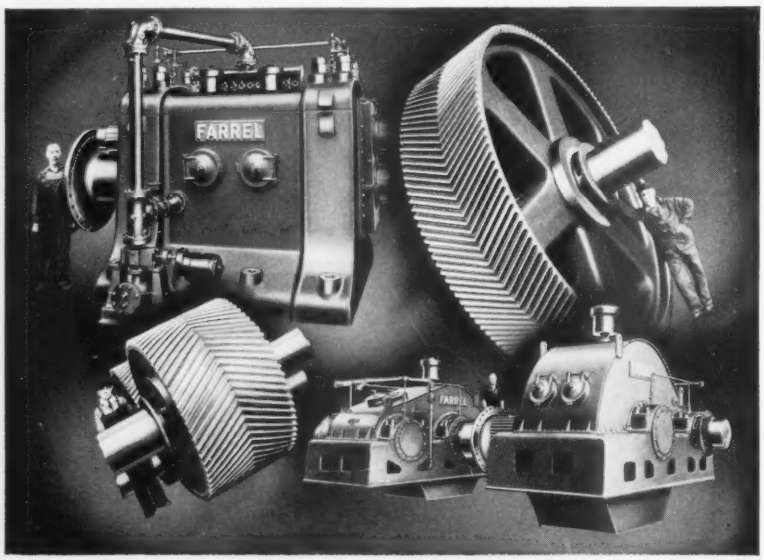
No. 2,106,803, APPARATUS FOR HANDLING STRANDS, Patented February 1, 1938 by Fred V. Johnson, Baltimore, Md., and Roland R. Nydegger, Wilmington, Del., assignors to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York.

Strands having a relatively high degree of torsional rigidity may be combined in such fashion that deformation imposed on individual strands will be distributed evenly along the strands, which are prevented from any lateral movement out of a predetermined path immediately and for some distance before they approach the point at which they are twisted together, by means of a guide comprising a plurality of elongated hollow members each to receive and pass one of the strands.

✦ ✦ ✦

No. 2,107,177, STRANDED CONDUCTOR, Patented February 1, 1938 by Homer W. Dudley, East Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York.

This invention aims to improve the design of stranded conductors to adapt them for efficient radio frequency transmission by reduction of the so-called



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The Gear with a Backbone

"skin effect" and "proximity effect" ordinarily encountered in high frequency stranded conductors, the design being such that the current density decreases from the surface to the center of the conductor. A multiplicity of re-entrantly stranded filamentary wires, some insulated, and others uninsulated, is provided, together with means binding the uninsulated wires to insure good electrical contact between the uninsulated wires at such points as they come together.

✦ ✦ ✦

No. 2,107,446, SPRING CUSHION STRUCTURE, Patented February 8, 1938 by Thomas Koliba, Detroit, Mich., assignor to L. A. Young Spring and Wire Corporation, Detroit, Mich.

Lapped upon and welded to a rectangular channelled border frame of special cross-sectional configuration to facilitate attachment of the upholstery are longitudinal and transverse cross-wires forming a supporting grid for the body springs.

✦ ✦ ✦

No. 2,107,719, WOVEN WIRE FABRICS, Patented February 8, 1938 by Ferdinand Steinhart, Kearny, N. J., assignor to The Lindsay Wire Weaving Company, Cleveland, Ohio, a corporation of Ohio.

The invention contemplates uniting the ends of twill woven wire cloths for Fourdrinier paper machines by removal of a plurality of the weft wires from the ends of the fabric to be joined, severing the warp wire ends so as to leave every third end bent downwardly, abutting the ends of the fabric, with the warp wires in alignment, and then welding, brazing or soldering the abutting warp wire ends.

✦ ✦ ✦

No. 2,107,745, APPARATUS FOR MAKING WIRE PRODUCTS, Patented February 8, 1938 by Albert F. Bradley, Sterling, Ill., assignor to Northwestern Barb Wire Company, Sterling, Ill., a corporation of Illinois.

A combined wire drawing and processing mechanism is provided, whereby the wire is continuously drawn, fed to and operated upon by the processing mechanism with substantially no interruption, the invention involving the provision of co-operating stepped wire drawing drums with means for compensating for variation in feed of the wire in the drawing mechanism and to provide proper tension of the wire between the drums.

✦ ✦ ✦

No. 2,107,799, HIGH SPEED WIRE DRAWING MACHINE, Patented February 8, 1938 by William D. Pierson and George W. Jackman, Waterbury, Conn., assignors to The Waterbury Farrel Foundry & Machine Company, Waterbury, Conn., a corporation of Connecticut.

This is a multiple-die machine of the cabinet type in which the wire may be strung up with a minimum loss of time, the sides of the cabinet being slotted to permit the dies to be strung upon the wire at spaced intervals before inserting the wire in the drawing machine. Means is provided for adjustably securing the final die to permit the proper casting of the wire as it is wound upon a finishing block after leaving the machine.

No. 2,107,810, WIRE LINE ENDS AND METHOD OF FORMING SAME, Patented February 8, 1938 by Earl E. Wherry, Oklahoma City, Okla.

In order to permit the threading of stranded cables, provided at their ends with attaching eyes, through restricted openings, such as pulley blocks and sheaves, the attaching eyes are formed of a width no greater than the diameter of the cables and are provided with pointed or tapered noses. The eye portion comprises at least one wire strand, substantially integral with the stranded cable. The method of forming this substantially integral eye portion includes removing one or more strands of the cable to a point spaced from the end of the cable and securing one or more arms of a stranded bight in the space or spaces formed by the removal of the strand or strands from the cable.

✦ ✦ ✦

No. 2,108,638, WIRE SCREENING APPLICATOR, Patented February 15, 1938 by Reuben Benedict, East Orange, N. J.

When screening is to be applied to a window or door frame, this tool will permit pulling the finally remaining loose edge of the screen into place for fastening. The device includes a jaw provided with a row of projecting pins for engaging an extended marginal portion of the screen, and a thumb-screw acting on the screen frame to pull the jaw in a manner to draw the edge of the screen into position.

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The Manufacture of Steel Wire And Some Related Processes

(*Continued from Page 176*)

THERE is also used, with the acid, a compound called an inhibitor. The inhibitor functions to retard the action of the acid on the steel after the scale has been removed. A compound is also used in the bath to build up a foam blanket on top of the bath to prevent loss by evaporation and to keep down fumes. After the scale has been removed, the rods, if they are to be bright coated, are immediately dipped into a light lime bath and placed in a baker.

✦ ✦ ✦

IF, however, a sull-coat is desired, then the rods are placed on a rack and a very light mist, or spray, of water, is allowed to play on the rods until the desired amount of sull-coating (wet rust) is formed. The rods are then coated with lime by dipping them into a heavier lime bath than that used for bright wire. Lime helps neutralize the acid and with the sull-coat, acts as a lubricant carrier in the subsequent wire drawing process. Sometimes other materials than lime are used for this purpose.

✦ ✦ ✦

IF lime has been used, then it is necessary to dry the coating by a process called baking. The baking takes place in an oven which is also designed to remove any hydrogen which may have been absorbed by the steel while it was immersed in the cleaning acid, and which later would tend to make the steel brittle if the amount absorbed was high enough. The use of an inhibitor in the acid pickling solution helps prevent hydrogen absorption by the steel. The baking of the lime is also necessary because wet rods cannot be successfully drawn, nor does wet lime act as a lubricant carrier. The bakers may be heated in any suitable manner, usually by means of fan-circulated heated air. The baking time may be from several hours in the ordinary baker to a very few minutes in the flash type baker.

✦ ✦ ✦

THE description, up to this time, refers to the cleaning of the low carbon type of steel, say carbons up to .25 per cent. The cleaning of high carbon rods, or wire, requires greater care to avoid the black deposits which may form on this class of material, and also to prevent the brittleness caused by hydrogen absorption, the latter being particularly harmful, especially when the wire is to be used for the manufacture of springs and the like. The coatings must be heavier to prevent scratching and run-outs, and as a rule, a longer baking time is desirable.

✦ ✦ ✦

THE cleaning department has been called "the heart of the wire mill."

Part II, "Wire Drawing," will be published in May issue of Wire and Wire Products.

Research on Fatigue Properties of Heavy Helical Springs

(*Continued from Page 185*)

SPRINGS SERIES F. TABLE XIII TESTS AT WRIGHT FIELD

Spring No.	Free Height	Solid Height	Total Deflection	Ratio Deflection / Solid Hgt.	Set in Inches: Static Loading Compression No. 1	Static Loading Compression No. 2	Static Loading Compression No. 3	Fatigue Loading No. of Cycles 5000	Fatigue Loading No. of Cycles 10000	Total Set	Load in lbs. used in Fatigue Test	Stress Rever-Wahl Formula	Number of Cycles to Failure
F-2	8.18"	5.32"	2.86"	.535	.03"	.01"	.01"	.01"	.00"	06"	3593	108000	95800
F-3	8.13"	5.29"	2.84"	.527	.02"	.01"	.01"	.01"	.00"	.05"	3326	100000	145000
F-5	7.92"	5.30"	2.62"	.495	.03"	.01"	.01"	.01"	.00"	06"	3060	92000	191600
F-6	7.73"	5.36"	2.37"	.443	.02"	.01"	.01"	.00"	.00"	.04"	2661	80000	632800
F-7	7.60"	5.30"	2.30"	.434	.02"	.00"	.01"	.01"	.00"	.04"	2794	84000	435300
F-9	7.56"	5.24"	2.26"	.432	.02"	.00"	.01"	.00"	.00"	.03"	2528	76000	726700
F-10	7.37"	5.25"	2.12"	.404	.01"	.00"	.00"	.00"	.00"	.01"	2262	68000	Note: 1628760
F-11	7.43"	5.22"	2.21"	.423	.01"	.00"	.00"	.00"	.00"	.01"	2462	74000	1980000

Note: Did not fail.

THE probable endurance limit found for Series "F",—namely, 71,600 p. s. i., is about 2,000 p. s. i. less than the limit determined for plain carbon basic, Series "A", and 4,000 p. s. i. less than for plain carbon electric, Series "E". It is a little better than the limit determined by Mr. Johnson in his original tests on plain carbon acid, —namely, about 68,000 p. s. i.

✦ ✦ ✦

TENSION and torsion tests resulted as follows:

	Tension	Torsion
Proportional Limit —p. s. i.	110000	62500
Yield Strength —p. s. i.	130000	85000
Ultimate Strength —p. s. i.	202300	161500
Modulus —p. s. i.	30000000	10800000
Elongation in 2" — %	8.5	.....

INFORMATION SERVICE

Manufacturers of materials, tools and equipment for wire drawing and forming plants are constantly making improvements and additions to their lines. If you do not find the product or service in which you are interested, additional information will be supplied promptly. Simply address:

WIRE & WIRE PRODUCTS

17 East 42nd Street New York City

Factors that Influence the Use of Metals

(*Continued from Page 193*)

the pure state. When two or more metals are combined to form a solid solution, this resistance to deformation is increased because of the presence of atoms of different size and the influence of this size difference on the slip or movement of the metal along planes of least resistance.

✦ ✦ ✦

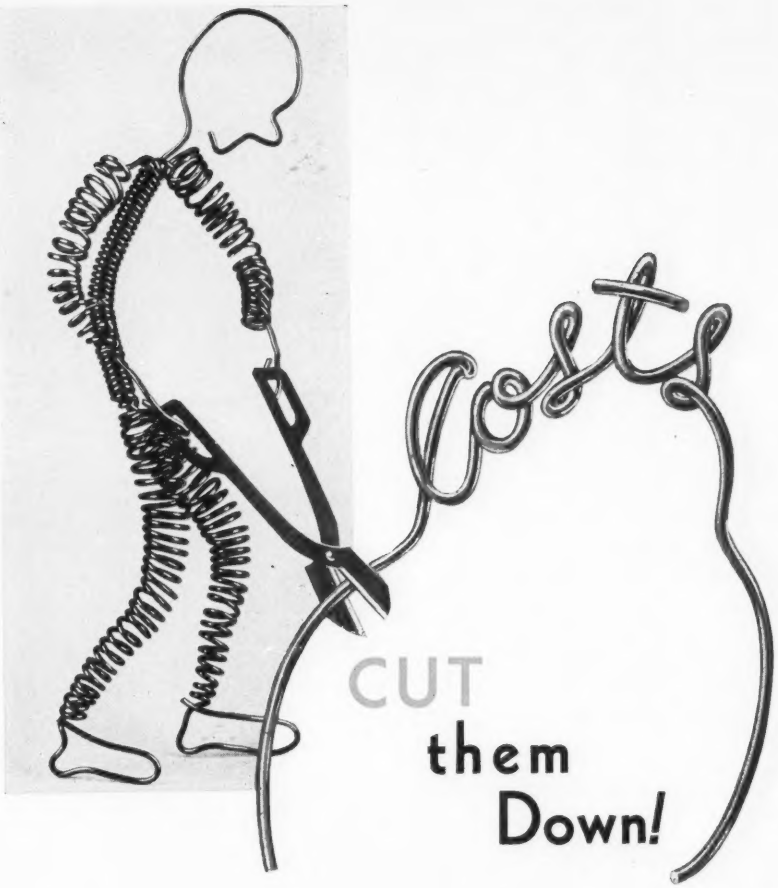
WHEN a metal is deformed, the activities of the forces of secondary valence, which tends to hold the atoms in a fixed relation to each other in the crystals, are increased. The reason for this lies in the fact that while they are always present they are continually seeking relief from strain through a balance of attractive and repulsive forces. Any movement or distortion of the metal upsets this equilibrium thereby increasing strain and the unbalanced forces are more active. When, as in the case of steel wire the deformation takes place at temperatures below the recrystallization temperature of the metal the strain resulting from cold work will persist and offer increased resistance to further deformation. When metals are cold worked at temperatures above their recrystallization temperature, relief of strain is continuous. Lead for example has a recrystallization temperature below room temperature. This enables us to continue cold working and accounts for its malleability and for the ease with which it is produced in extremely thin sections.

✦ ✦ ✦

Recrystallization Temperatures

WHILE the difference between hot and cold working appears to be associated with heat, it is in reality the difference between working the metal above or below its recrystallization temperature. Lead can be cold worked at room temperature yet as far as our ability to make enormous reduction it is much the same as working steel at 1800°F. Tungsten can be worked at a temperature of

(*Please turn to Page 208*)



Start the proper grade of Keystone wire going through your machines, and watch it snip sizable margins from the costs. By "proper grade" we mean a wire that will bend, weld, form or fabricate to produce the best finished product at least manufacturing cost.

If a regularly stocked wire doesn't meet ALL your requirements, our technical staff will help develop one that does. Write and put it up to us to SHOW what this little cost-cutter can do in your plant.

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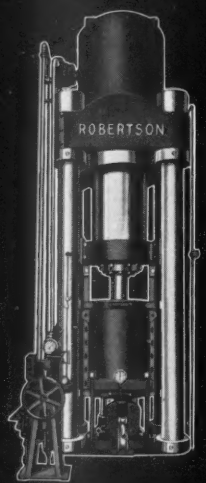

ROBERTSON LEAD ENCASING HYDRAULIC PRESS

JOHN ROBERTSON COMPANY, INC.
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Some Scientific Aspects of the Pickling Problem

(*Continued from Page 180*)

Hydrogen Embrittlement

CERTAIN inhibitors, such as quinoline and pyridine, cause a considerable decrease in absorption of hydrogen during pickling (Wardell), while others, such as glue, have no such effect.

✦ ✦ ✦

EXPERIMENTS conducted by Bardenheuer and Ploum show that the original ductility before pickling is never fully restored after pickling and baking. This is probably due to a certain amount of loosening of the structure of the metal due to expansion and contraction of the crystalline lattice during the absorption and elimination of hydrogen.

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HYDROGEN sometimes accumulates in the form of blisters, which may appear on pickling or after annealing or hot galvanizing.

✦ ✦ ✦

EDWARDS has shown that hydrogen in gaseous form may become localized at spots of iron oxide or sulphur inclusions, and Bardenheuer and Thanheiser have found that segregated and gassy steels are more likely to exhibit these bubbles. The pressure in such gas pockets may rise to such value as to rupture the steel.

✦ ✦ ✦

Oxides in Scale

X-RAY research at the National Physical Laboratory has established that the oxides on scale are Fe O, Fe^2O^3, and Fe^3O^4. Their character depends on the rolling temperature. At high rolling temperatures the scale is blue-black (Fe^3O^4), at low temperatures reddish (Fe^2O^3), this ferric oxide being powdery and covering an underlying layer of Fe^3O^4.

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SCALE on castings contains silica and forms a better base for paint than rolling scale (Turner, Daeves).

✦ ✦ ✦

THE thickness of scale films is very variable; Jenkins, Wintterbottom and Lewis, using microscopic methods, have established mean values between 0.01 and 0.07 millimeters, with limiting figures of 0.001 and 0.2.

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✦ ✦ ✦

New Wire Handbook

THE Alloy Metal Wire Company of Prospect Park, Pa., has just published for all users of wire, rod and strip in the electrical, chemical and mechanical fields, a helpful handbook of information and data on alloys.

✦ ✦ ✦

THIS booklet contains finger-tip facts on the wide variety of alloys used in wire, rod and strip form. In addition to listing the descriptions, application, and price per pound of alloys, it contains wire data, the range of uses, current temperature characteristics of wire, resistance, and feet per pound.

✦ ✦ ✦

IN the electrical field, where high temperatures and resistance to oxidation are most important, data on the forms of alloys to be used is set forth. For the engineer desiring facts on alloys, both of high electrical resistance used in all types of electrical measuring instruments and fine low temperature resistance units . . . this booklet supplies the data for the problem in hand. Recommended uses and data on wire, rod and strip of monel and non-corrosive steel are also given. Copies of this handbook may be obtained by addressing the Editor of Wire & Wire Products.

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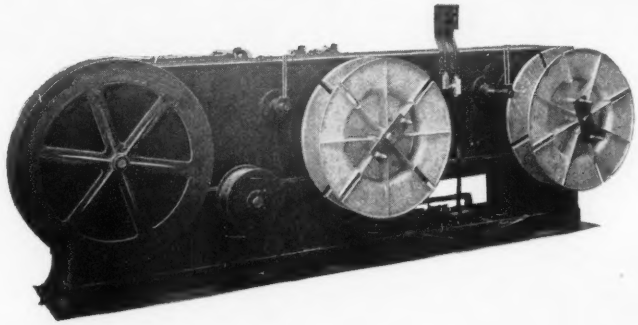

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Factors that Influence the Use of Metals

(*Continued from Page 205*)

2000°F and still the strains resulting from deformation will be present.

✦ ✦ ✦

IN table III is shown a list of the recrystallization temperatures of 15 metals, according to Jefferies and Archer.*

✦ ✦ ✦

TABLE III

Approximate Lowest Recrystallization Temperature

Metal	Temperature Degrees Fahrenheit
Iron	842
Nickel	1112
Gold	392
Silver	392
Copper	392
Aluminum	302
Platinum	842
Magnesium	302
Tantalum	1832
Tungsten	2192
Molybdenum	1652
Zinc —Room Temperature	
Lead — Below Room Temperature	
Tin — Below Room Temperature	
Cadmium—About Room Temperature	

IF as a result of cold working a metal becomes too hard for further working, heating to above its recrystallization temperature will afford relief of strain and cold working can be continued.

✦ ✦ ✦

THE deforming of metals means the development of slips along planes resulting from the geometrical arrangement of the atoms. If the strain is excessive and beyond the amount of cohesion which exists as a result of the force of secondary valence, fracture will result. Metals or alloys wherein slips occur easily and unobstructed are ductile. If, however, precipitated constituents are present which interfere with this slip, along the planes of least resistance, then the strength of the alloy will be increased.

✦ ✦ ✦

IN a given metal or solid solution regardless of the presence of precipitated constituents, the slip which takes place is confined to groups of crystal units termed

(*Continued on Page 212*)

The Problem of Employment of Men Over Forty

(*Continued from Page 181*)

their professional examinations, but in fairness to all unemployed citizens it is believed that certain rigid age requirements should be modified for especially capable applicants over 40 years of age.

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AN employer of labor in the steel industry on the average must have a capital expenditure of at least $12,000 per man to give employment—in some cases the figure runs as high as $16,000 investment per man. As aforestated, 40% of employes for the nation to date in the durable goods industry average over 40 years, therefore, it is logical to assume that other employers in any industry may take a lesson and realize the **faith** such a stupendous industry places in men past 40 to manipulate, manufacture and handle so great an investment. On the other hand, an unemployed citizen should appreciate his responsibility towards capital or his employers, and when given an opportunity should give his hour's-work-for-pay-received, bearing in mind service and quality of product for his customers that he indirectly serves combined with enough energy and skill on his particular job to pay his proportionate share to let business carry on to make some profit and to pay the ever increasing burden of taxation. A fair-minded and broad-gauged employer naturally appreciates experience, stability and other attributes of mankind regardless of whether he is over forty.

✦ ✦ ✦

THE fourth phase presents itself as follows:-

✦ ✦ ✦

LET me repeat again a part of that preamble of the American Legion Constitution: "To foster and perpetuate one hundred per cent Americanism". There is that old fashioned word, namely loyalty. If we stop to analyze that word we shall realize that the strength of loyalty lies only with strong character and strong men because they choose the better things before they will establish their unwavering loyalty. Today this world is in a turmoil with insidiousness—Com-

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munism of Russia, Nazism of Germany, Fascism of Italy and a crazy radicalism by some in America. Let me impress upon you that these veterans averaging 44 years of age and these citizens over 40 years of age with their matured judgment understand steadfast loyalty, and are some of the best defenders of our American System. Of course, there are exceptions to all of this and a few are cynical, but the vast majority are loyal to the last. If you don't have any of these red-blooded loyalists about you—give them a chance—some day you may need them, as the nation did twenty years ago, whether it be the citizens that toiled to back up the armed defenders, or the veterans who sacrificed and fought out there directly for our country.

✦ ✦ ✦

New Cable Handbooks

ANACONDA Wire and Cable Company announces the publication of two new handbooks.

1. The Parkway Cable Handbook which discusses the application, construction and physical properties of Parkway Cable together with information relating to "Current Carrying Capacities" and cable jointing instructions.

2. The Varnished Cambric Cable Handbook which is a carefully prepared study on the correct uses of Varnished Cambric Cable, the various types physical properties and characteristics. In addition to this valuable information, there is a series of new tables relating to recommended thickness of insulation, tests and new current capacities data for use of this cable in both air and ducts. The concluding pages give recommended instructions for making straight joints on Varnished Cambric Cable.

✦ ✦ ✦

EITHER publication may be obtained by addressing the Anaconda Wire and Cable Company, 25 Broadway, New York, N. Y. or the Editor of WIRE AND WIRE PRODUCTS.

The Detroit-Leland Hotel will be headquarters for the 1938 Wire Association Meeting in Detroit.

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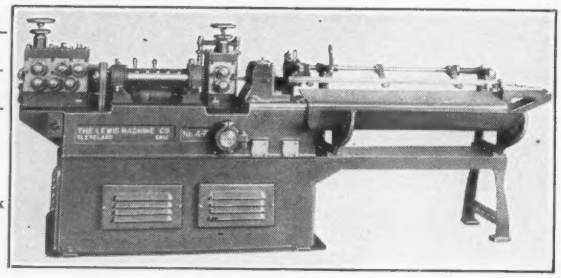

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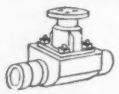

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General Discussion on Lubrication And Lubricants

THE Institution of Mechanical Engineers in London, announces that the Proceedings of the General Discussion on Lubrication and Lubricants will be available towards the middle of March in two bound volumes comprising some 1200 pages.

✦ ✦ ✦

SOME 29 British and 22 foreign societies agreed to collaborate and, as a result, 136 papers were received. The papers dealt with the major problems of the subject —practical and theoretical and the correlation of these aspects—the application of bearing design, the relationship of academic research and trade practice, statements of current views on bearing metals, and the significance of laboratory tests, including wear and friction tests. The papers, together with the summaries by the reporters, the accounts of the discussions, and the collated replies by the authors, constitute an invaluable compendium of current information on lubrication, and an important addition to its literature.

✦ ✦ ✦

COPIES may be obtained for 25 shillings by addressing J. E. Montgomery, Acting Secretary The Institution of Mechanical Engineers, Storey's Gate, St. James Park, London, S.W.1, England.

✦ ✦ ✦

Du Pont Forms Electroplating Chemicals Division

FORMATION of the Electroplating Chemicals Division is announced by E. I. du Pont de Nemours & Company, designed to correlate the various manufacturing departments of the Company contributing to the plating industry.

✦ ✦ ✦

THE new division, headed by J. C. Pickard, has as its aim a unified position from which to service the trade, providing such technical assistance as may be occasioned. The division will handle all du Pont products having a place in the electroplating field, particularly the materials made by the Grasselli and the R. & H. Chemicals Departments.

Gustav A. Merkt

GUSTAV A. Merkt, Manager Combustion Control Department, of the Morgan Construction Company, Worcester, Massachusetts, died recently. For many years he had been associated with the steel industry, having held engineering positions with the American Steel & Wire Company and the Wickwire Spencer Steel Corporation. In 1925 he joined the staff of the Morgan Construction Company as a consultant, and later succeeded the late George H. Isley as Manager of the Combustion Control Department. He was an active member of the American Society of Mechanical Engineers.

✦ ✦ ✦

Metal Coating Processes

"METAL Coating Processes" is the title of Calibron Notebook No. 4 published by the Calibron Products, Inc., West Orange, N. J.

✦ ✦ ✦

THIS deals primarily with the new "Martin Process" based upon reactions between gases and solids, and also with the diffusion of metals — an important part of the Martin Process. It is claimed that coatings obtained by this new process possess a combination of characteristics not found in coatings produced by electroplating, hot-dipping, spraying, or cementation. The new coatings are extremely tenacious, as they actually become integral with the body metal; they are uniform, even in holes and other places difficult of access; surface details are minutely preserved, as the coatings are formed by replacement rather than by simple addition; and finally, the coatings are bright—usually forming alloys with the base metal.

✦ ✦ ✦

COPIES of the bulletin may be obtained by addressing the Editor of WIRE AND WIRE PRODUCTS.

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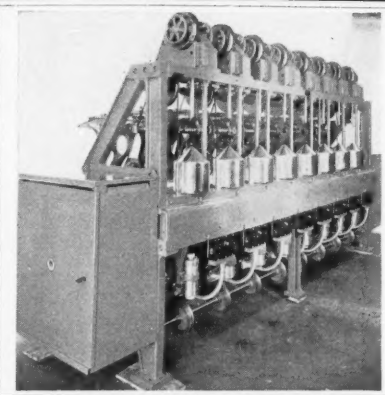

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Factors that Influence the Use of Metals

(*Continued from Page 208*)

grains. The reason for this is that the grain boundaries offer obstruction to slip and while all the grain may contain slips the same movement is not continuous from one grain to another. If a large grain size is present, more freedom for slip or more ductility will result, if, however, the grains are small the slip within the individual grains will be small and resistance to deformation will be built up which will again increase the strength of the metal or alloy. It is obvious from this that the whole structure on which the physical characteristics depend is based on the resistance of slip along cleavage planes resulting from atomic arrangements of the various elements. This applies both to the solid solution type wherein different sized atoms afford resistance, to the precipitated constituent type of resistance wherein the precipitate distributed in the form of fine particles afford obstruction and the control of grain size which provides an increase in resistance because of an increased number of grain boundaries.

* * *

THESE fundamentals of cold working are not confined to deforming operations such as wire drawing or cold heading but represent the means by which all changes of shape are resisted whether it be compression, tension, hardness or ductility tests. It is this resistance or lack of resistance to deformation which determines physical characteristics.

* * *

Powder Metallurgy

A COMPARATIVELY new development in the improvement of physical properties in metals is known as Powder Metallurgy. By this process, which consists of mechanically producing a distribution of fine hard particles in intimate relation to softer particles, by means of sintering and the use of extreme pressure, it is possible to produce metals with a degree of hardness approximating that of the diamond, yet with sufficient ductility to permit of their use for applications where resistance to shock is important, as for example, lathe tools. The hard constituent which consists of a carbide of tungsten, tantalum or other metals, is present in a large amount and in such fine dispersion as to present a uniform hard surface. This new material, to which the name Cemented-Carbides has been given, is used extensively for machining purposes, as dies in the drawing of wire and cold heading, and for other purposes wherein extreme hardness and maximum resistance to abrasion are important.

* * *

BY alloying, heat treatment and cold work as shown above, the physical characteristics of metals can be developed for specific purposes. This is without question the most important factor which influences the uses of metals.

* * *

Outstanding Personalities of the Wire Industry

(*Continued from Page 195*)

& Wire Co. for over five years, has been appointed Superintendent of the company's Allentown, Penna. Works, succeding James S. Phifer, deceased.

* * *

MR. Patt started working for the Wire Company in September, 1905, employed as a clerk in the Order and Warehouse Department. He filled various positions with the company until in 1931 he was appointed Manager's Representative at Pittsburgh, which post he held until being made Assistant Superintendent at Donora in September, 1932.

* * *

BORN in Shelbyville, Ill., on March 11, 1884, Mr. Patt attended Doane Academy at Granville, Ohio, and later attended Denison University, being graduated with an A.B. degree.

*The Science of Metals by Jefferies and Archer Page 86 McGraw Hill Book Co., New York City.

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Exports and Imports of Wire

(*Continued from Page 197*)

EXPORTS of iron and steel wood screws during January, 1938 totaled 23,520 gross valued at $3,616. Of this total Cuba took 6,214 gross valued at $972; Mexico 5,535 gross valued at $825; Chile 4,453 gross valued at $530; Venezuela 1,396 gross valued at $143; Canada 1,191 gross valued at $163.

✦ ✦ ✦

EXPORTS of brass wood screws during the same month totaled 4,982 gross valued at $1,597. Of this total Colombia took 2,160 gross valued at $278; Cuba 673 gross valued at $455; Brazil 400 gross valued at $174; Costa Rica 400 gross valued at $92; Canada 349 gross valued at $238.

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Morrison Engineering Co., Cleveland, O.

BORON CARBIDE—
Norton Co., Worcester, Mass.

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Magnus Chemical Co., Garwood, N. J.

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Norton Co., Worcester, Mass.

CHEMICALS—Cleaning
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Magnus Chemical Co., Garwood, N. J.
Parkin, Wm. M., Co., The, Pittsburgh, Pa.

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Magnus Chemical Co., Garwood, N. J.

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Duriron Co., The, Dayton, O.
Haveg Corp., Newark, Del.
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

COATING—Protective
American Lanolin Corp., Lawrence, Mass.

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Farrel-Birmingham Co., Inc., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

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Youngstown Sheet & Tube Co., Youngstown, Ohio.

CONTROLS—Automatic
Leeds & Northrup Co., Philadelphia, Pa.

CRANES—Block Stripping
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

CRANES—Cleaning House
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

CRANES—Electrical Traveling
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

CRANES—Wire Mill
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

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Cochaud Wire Die Co., New York, N. Y.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.

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John Robertson Co., Brooklyn, N. Y.

DIES—Repairs & Re-Cutting
Balloffet Dies & Nozzle Co., Inc., Guttenberg, N. J.
Carboloy Co., Inc., Detroit, Mich.
Cochaud Wire Die Corp., New York, N. Y.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.

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Carboloy Co., Inc., Detroit, Mich.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.

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WHERE TO BUY, Continued

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Rusch Wire Die Corp., New York, N. Y.
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Carboloy Co., Inc., Detroit, Mich.
Firth-Sterling Steel Co., McKeesport, Pa.
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Vaughn Machinery Co., Cuyahoga Falls, O.

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FURNACES—Hardening and Tempering
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Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Lead Melting
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Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Galvanizing Wire
Broden Construction Co., Cleveland, O.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Gang Winders
Fidelity Machine Co., Philadelphia, Pa.
H. J. Ruesch Machine Co., Newark, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Grinding
Norton Co., Worcester, Mass.

MACHINERY—Insulating
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lead Encasing Presses, etc.
John Robertson Co., Brooklyn, N. Y.

MACHINERY—Lead Stripping
John Robertson Co., Brooklyn, N. Y.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lock Washer
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Magnet Wire
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Material Handling
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

MACHINERY — Measuring Wire & Cable
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Nail and Tack
Glader, Wm., Machine Works Co., Chicago, Ill.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Panning
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

MACHINERY—Pointing
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Rod Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.

MACHINERY—Rolling Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Inc., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Rubber Strip Covering
Farrel-Birmingham Co., Inc., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Rubber Tubing and Straining
Farrel-Birmingham Co., Inc., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Royle, John, & Sons, Paterson, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Screw Wire
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Special
Amer. Insulating Mach'y Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

WHERE TO BUY, Continued

MACHINERY— Special — Combination Machine for Drawing, Cutting-to-length. Straightening and Reeling Bars from Coil in One Operation (Shumag Type)—
W. A. Schuyler, New York, N. Y.

MACHINERY—Spooling
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
Sleeper & Hartley Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Watson Machine Co., Paterson, N. J.

MACHINERY—Spring Making
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Staple
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Straightening
Broden Construction Co., Cleveland, O.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
National Machinery Exchange, New York, N. Y.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.
F. B. Shuster, New Haven, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Stranding
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Strip Steel
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Swaging
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Taping
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Testing Size of Wire
Torrington Mfg. Co., Torrington, Conn.

MACHINERY—Tinsel Rolling Mills
Amer. Insulating Mach'y Co., Phila., Pa.

MACHINERY—Trolley Wire
Vaughn Machinery Co., Cuyahoga Fall, O.

MACHINERY—Tube Mill
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Welding Wire
Micro Products Co., Chicago, Ill.
F. B. Shuster Co., New Haven, Conn.
Thomson-Judd Wire Machinery Co., Lynn, Mass.

MACHINERY—Winding
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Drawing
Amer. Insulating Mach'y Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
Morgan Construction Co., Worcester, Mass.
National Machinery Exchange, New York, N. Y.
H. J. Ruesch Machine Co., Newark, N. J
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Wire Rope
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Tinning
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

MACHINERY—Wrapping Wire
Elevator Supplies Co., Inc., Rahway, N. J.
W. A. Schuyler, New York, N. Y.

MATERIAL HANDLING EQUIPMENT—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

MILLS—Tandem Rolling and Edging
Torrington Mfg. Co., Torrington, Conn.

MONORAIL SYSTEMS—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

NICKEL SILVER AND PHOSPHOR BRONZE—Rod, Wire and Strip
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., The, Seymour, Conn.

PAPER—Insulating
E. W. Twitchell, Inc., Phila., Pa.

PATENT ATTORNEYS—
Lancaster, Allwine and Rommel, Washington, D. C.

PICKLING COMPOUNDS—
American Chemical Paint Co., Ambler, Pa.
Parkin, Wm. M., Co., The, Pittsburgh, Pa.

PIPING AND FITTINGS—Acid Resistant
Haveg Corp., Newark, Del.

POTS—Lead Melting
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Hydraulic and Mechanical
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Lead
John Robertson Co., Brooklyn, N. Y.

PULLERS—Wire
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

PUMPS—Hydraulic
John Robertson Co., Brooklyn, N. Y.

PYROMETERS—
Leeds & Northrup Co., Philadelphia, Pa.

RECORDERS—
Leeds & Northrup Co., Philadelphia, Pa.

REEL AND TENSION STAND—
Fidelity Machine Co., Philadelphia, Pa.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

REEL CRUTCHES—
Watson Machine Co., Paterson, N. J.

REELS AND SPOOLS—Shipping and Shop
Stevens Metal Products Co., Niles, O.

REFRACTORIES—High Temperature
Norton Co., Worcester, Mass.

ROD BAKERS—
Morrison Engineering Co., Cleveland, O.

RODS—Stainless Steel
Rustless Iron & Steel Corp., Baltimore, Md.

RODS—Wire—Non Ferrous
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., The, Seymour, Conn.

RODS—Wire—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

ROLLS—
Farrel-Birmingham Co., Inc., Ansonia, Conn.

RUST PROOF COMPOUND—
American Lanolin Co., Lawrence, Mass.

SHEET—Steel
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

SKIN PROTECTOR—
Magnus Chemical Co., Garwood, N. J.

SOAPS—Industrial and Wire Drawing
Magnus Chemical Co., Garwood, N. J.

STAINLESS STEEL—
Rustless Iron & Steel Corp., Baltimore, Md.

STRIP—Brass, Zinc and Non Ferrous
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., The, Seymour, Conn.

STRIP—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Firth-Sterling Steel Co., McKeesport, Pa.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.

TANKS—Compound
Watson Machine Co., Paterson, N. J.

TANKS—Pickling
Haveg Corp., Newark, Del.

TRAMRAIL SYSTEMS—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

TREADS—Safety
Norton Co., Worcester, Mass.

TRUCKS
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Fall, O.

TUBE BENDERS AND FORMERS—
H. J. Ruesch Machine Co., Newark, N. J.

VALVES AND FITTINGS—Acid Proof
Duriron Co., The, Dayton, O.
Haveg Corp., Newark, Del.

VULCANIZERS—
Watson Machine Co., Paterson, N. J.

VULCANIZING PANS—
Amer. Insulating Mach'y Co., Phila., Pa.

WELDERS—Spot and Butt
Micro Products Co., Chicago, Ill.

WIRE—Cold Heading
Bethlehem Steel Co., Bethlehem, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Electric
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

WIRE—Enameled For Coils
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Manufacturers
Bethlehem Steel Co., Bethlehem, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Nickel Silver and Phosphor Bronze
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

WIRE—Non Ferrous to Specification For Special Purposes
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Spring
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Stainless Steel
Rustless Iron & Steel Corp., Baltimore, Md.

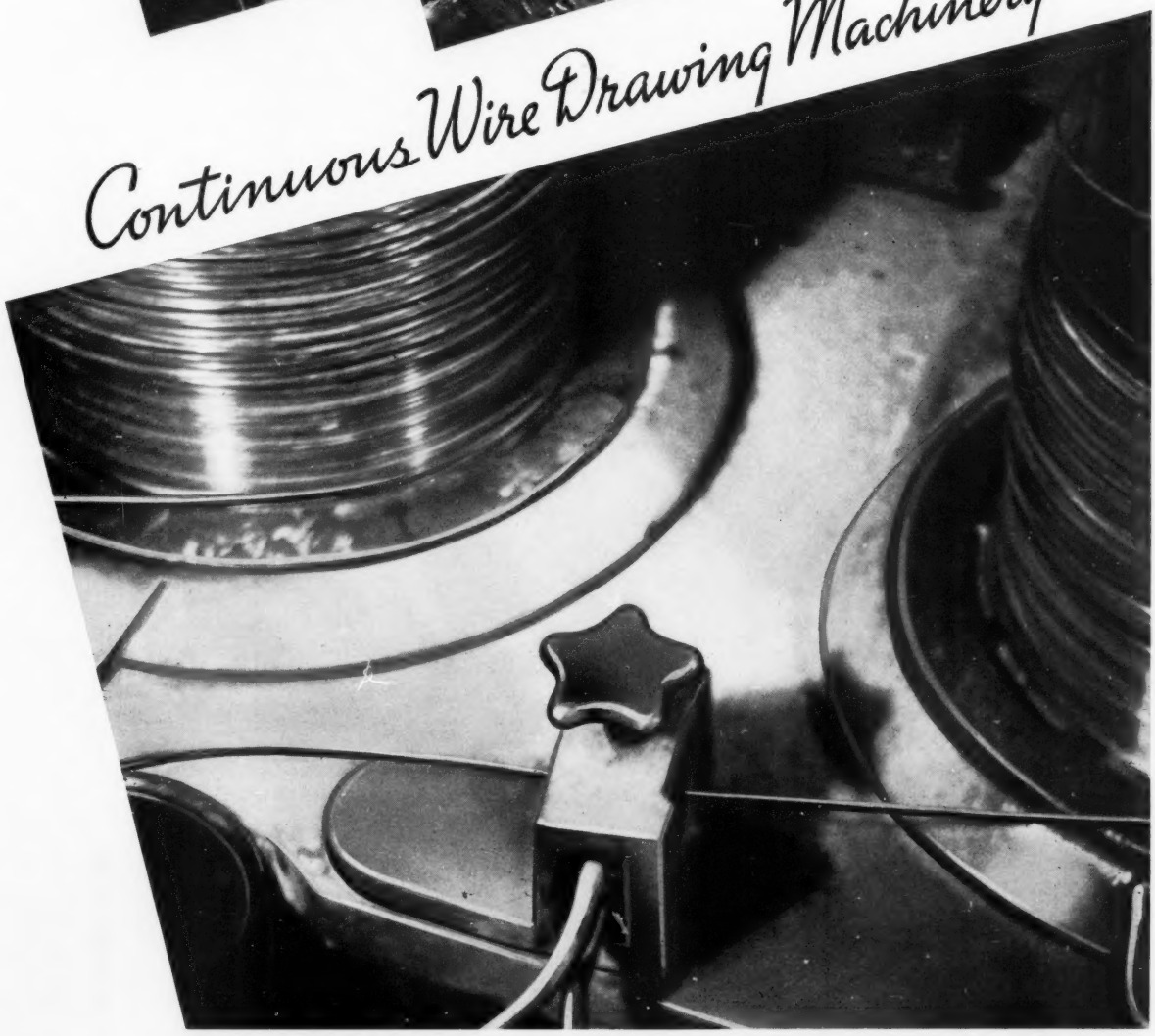
WIRE—Steel—Also Coppered Steel—Also Galvanized Steel
Bethlehem Steel Co., Bethlehem, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE AND STRIP—Brass, Zinc
Platt Bros. & Co., The, Waterbury, Conn.

MORGAN-CONNOR

Morgan-Connor Wire Machines cool as they coil. The wire is accumulated on high blocks without slip or interruption of the drawing process, and its temperature is reduced by air cooling. This exclusive method of storing and cooling permits drawing at high speeds of both high and low carbon stock. It also assures close uniformity of product and unequalled output per unit of labor. Morgan Construction Co., Worcester, Mass., U. S. A.

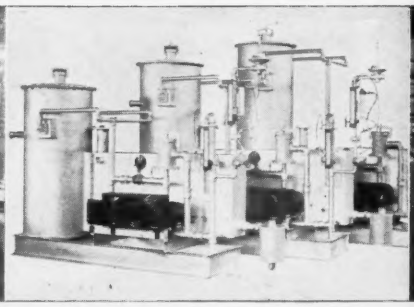
Continuous Wire Drawing Machinery



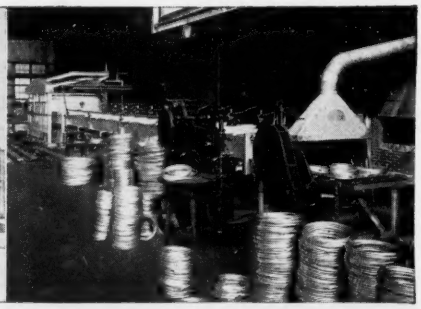
Sole European Representatives — Malmedie & Co., Dusseldorf, Germany

W26

Coiled strip as well as brass, copper, bronze and nickel-silver wire in large coils is bright annealed in this continuous special atmosphere furnace.



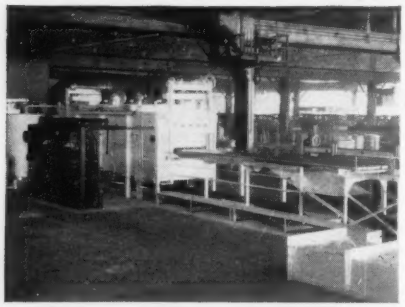
3 standard sizes of Elfurno generators for producing the inexpensive protective atmospheres used in controlled atmosphere furnaces. Elfurno generators are built for any capacity required.



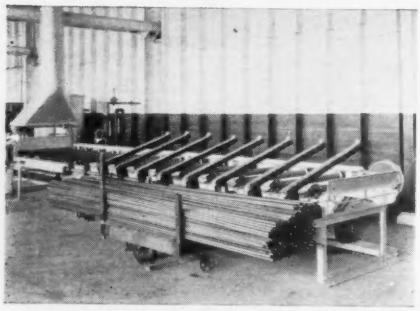
A continuous furnace equipped with The Electric Furnace Company's new recuperative type gas fired, radiant tubes, bright annealing copper tubing in coils.

Bright Annealing Wire, Strip,

Tubing, Etc. . . . Continuously



Bright annealing copper tubing in straight lengths —various diameters and lengths are handled continuously in this special atmosphere electric furnace.



Discharge end of another continuous controlled atmosphere furnace for bright annealing tubing. The material is automatically unloaded onto trucks.

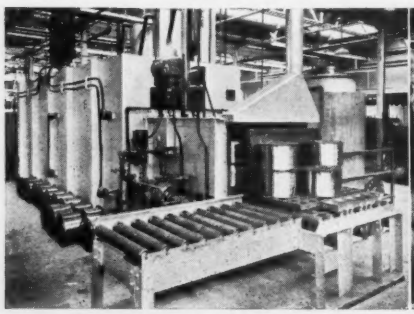
The Electric Furnace Company has made a number of outstanding electric and fuel fired special atmosphere furnace developments and installations for bright and clean annealing steel, copper, brass, bronze and nickel-silver parts and products including strip, stampings, tubing, wire, etc. A few furnaces we have built for non-ferrous products are shown above and below.

We build continuous and batch type furnaces for practically every product and for any production — for annealing, normalizing, copper brazing, silver soldering, scale-free hardening, drawing, carburizing, heating for forging and for every other industrial heating or heat treating process.

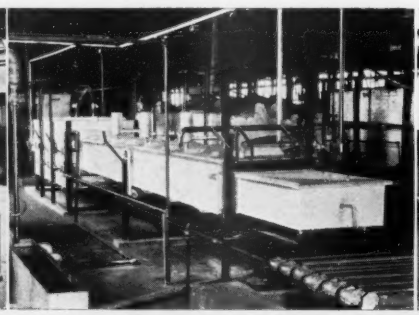
We build gas fired, oil fired, or electrically heated furnaces— whichever is best for the particular plant, process or product. Consult with us on any of your furnace or heat treating problems. No job is too large or too unusual.

The Electric Furnace Co., Salem, Ohio

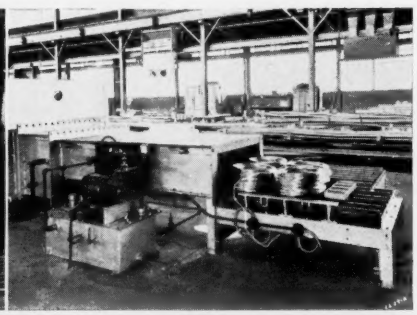
Gas Fired, Oil Fired and Electric Furnaces — For Any Process, Product or Production



Copper wire on large reels is bright annealed in this continuous furnace — capacity 36,000 lbs. per day. The wire comes out uniformly annealed, bright and dry.



Bright annealing fine copper wire on small spools. This furnace handles 10,000 lbs. per day. All these furnaces can be built in larger or smaller sizes.



Charging end of another continuous, controlled atmosphere electric furnace for clean annealing large coils of bronze, copper and nickel-silver wire.